THE

MINING MAGAZINE

AND

JOURNAL OF GEOLOGY,

Mineralogy, Metallurgy, Chemistry, and the Arts,

IN

THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

EDITED BY

WILLIAM P. BLAKE,

GEOLOGIST AND MINING ENGINEER.

SECOND SERIES.

VOLUME ONE.

NOVEMBER, 1859, TO JULY, 1860.

[Being the continuation of the "Mining and Statistic Magazine," from Vol. XI, No. 4, October, 1858.]

NEW YORK AND NEW HAVEN.

1860.

INDEX TO VOL. I, NEW SERIES.

W.

Y.

Z.


MAP OF
ARIZONA
(or the)
GADSDEN PURCHASE
with the Position
of its
SILVER MINES
as now worked
1859.
ARIZONA
MEXICO
Fort Yuma
Gila River
Great California Overland Mail Route
Semi Weekly
Santa Cruz R.
San Pedro R.
Rio Grande
Tucson
S. Xavier
Ajo Copper M.
Sopori Rancho
Heintzelman M.
Fort Buchanan
Santa Rita Mines
Sonoita Valley
Tubac
Arivaca Rancho
Calabazas Rancho
Santa Cruz
La Puerta
Mesilla
Fort Fillmore
El Paso
TEXAS
Colorado
LOWER CALIFORNIA
GULF OF CALIFORNIA
CALIFORNIA
NEW MEXICO
ARIZONA
Tucson
Tubac
Heintzelman Silver mine
El Paso
San Diego
PACIFIC OCEAN
LOWER CALIFORNIA
GULF OF CALIFORNIA
SONORA
Altar
Arispe
Hermosillo City
MEXICO
CHIHUAHUA
Guyamas
Alamos
SINALOA

THE

MINING MAGAZINE

AND JOURNAL OF

GEOLOGY,

MINERALOGY, METALLURGY, CHEMISTRY, AND THE ARTS IN THEIR APPLICATIONS TO THE MINING AND WORKING OF USEFUL ORES AND METALS.

NOVEMBER, 1859.

ART. I.—SILVER AND COPPER MINING IN ARIZONA,* WITH A MAP.

THE proposed new Territory of Arizona, better known as the Gadsden Purchase, lies between the thirty-first and thirty-third parallels of latitude, and is bounded on the north by the Gila River, which separates it from the territory of New Mexico; on the east by the Rio Bravo del Norte (Rio Grande), which separates it from Texas; on the south by Chihuahua and Sonora, Mexican provinces; and on the west by the Colorado River of the West, which separates it from Upper and Lower California. This great region is six hundred miles long by about fifty miles wide, and embraces an area of about thirty thousand square miles. It was acquired by purchase from Mexico, during the mission of General Gadsden, at a cost of ten millions of dollars. At that time there was scarcely any population, except a few scattering Mexicans in the Mesilla Valley, and at the old town of Tucson, in the centre of the Territory. The marauding Apache Indians had gradually extirpated almost every trace of civilization in what was once a thriving and populous Spanish Province.

* Compiled for the *Mining Magazine*, from the various Reports and Statements of Messrs. Brunckow, Ehrenberg, Poston, Mowry, Parke, Emory, Bartlett, Parry, Schott, Gray, Blake, Ward, Wilson, and others.

Much interesting information upon the early history of this comparatively little known part of the United States, was obtained from the archives of the Mexican Government, by Capt. C. P. Stone, late of the U. S. Army. It appears that as early as 1687 a Jesuit missionary from the province of Sonora, which, in its southern portion, bore already the impress of Spanish civilization, descended the valley of Santa Cruz river to the Gila, which he followed to its mouth, now the site of Fort Yuma. From this point he ascended the valley of the Gila, the Salinas or Salt River, and other branches. Proceeding east, he explored the Valley of the San Pedro and its branches, reached the Mimbres, and probably the Rio Grande and the Mesilla Valley. Filled with the enthusiasm of his sect, he procured authority from the head of the order in Mexico, and established missions and settlements at every available point. In a report to the Viceroy of Spain, made during the early settlement of the Province, we find the following statement: "A scientific exploration of Sonora, with reference to mineralogy, along with the introduction of families, will lead to a discovery of gold and silver, so marvellous, that the result will be such as has never yet been seen in the world." A map of this and the adjoining territories was drawn by some of the Jesuit missionaries in 1757, and dedicated to the King of Spain.

The reports of the immense mineral wealth of the new country made by the Jesuits, induced a rapid settlement. The sites of more than forty towns and villages, some of them of considerable size, are indicated on the map. These settlements and missions were founded by the side of streams and springs in fertile valleys, which produced luxuriant crops of wheat, corn and beans, and in many parts grapes and other foreign fruits were cultivated. In the western part of the territory were the missions of St. Pierre, St. Paul, St. Matthias, St. Simond, St. Francisco Merci; the ranchos of Eau Cheri, Eau de la Lune, and others; on the Santa Cruz, the missions of San Xavier del Bac, Santiago, San Cayetano, and San Felipe, the towns of Tucson, Tubac, Reges, San Augusta and many others. San Xavier del Bac is still in existence. It is a mission Church of great size and beauty, magnificently ornamented within; forty thousand dollars worth of silver being used to adorn the altar. Upon the San Pedro river were the missions of St. Mark, San Salvador, Santa Cruz, and the

towns of Quiduria, Rosario, San Fernando, and others. To the east, some small settlements were found in the Valle del Sauz, on the Mimbres, at the copper mines north of the Mimbres, and to the south the immense grazing and stock-raising establishment of San Bernardino, where hundreds of thousands of cattle and horses have since been raised. The Indians in the vicinity of the missions were reduced first to obedience by the Jesuits, and then to slavery by the Spaniards.

The missions and settlements were repeatedly destroyed by the Apaches, and the priests and settlers massacred or driven off. The Indians, at length thoroughly aroused by the cruelties of the Spaniards, by whom they were deprived of their liberty, forced to labor in the silver mines with inadequate food, and barbarously treated, finally rose, joined with tribes who had never been subdued, and gradually drove out or massacred their oppressors. Civilization disappeared before their devastating career, and in its place we now find, with few exceptions, only ruins and decay, fields deserted, and mines abandoned. The mission of San Xavier del Bac, and the old towns of Tucson and Tubac, are the most prominent of these remains. The mission of San Xavier del Bac is a grand old structure, which, from its elegant masonry and tasteful ornaments, must have been erected in times of great prosperity.

From 1757 down to 1820, the Spaniards and Mexicans continued to work many valuable mines near Barbacora, and the ancient records and notes mention many silver mines, most of which contain a per centage of gold. Among them were the Dolores, San Antonio, Casa Gordo, Cabrisa, San Juan Batista, Santa Ana, (which was worked to the depth of three hundred and sixty feet), Rosario, Cata de Agua, Guadalupe, Connilla, Prieta, Santa Catarina, Guzopa, Hurstano, Arpa, Descuhidora, Nacosare, Arguage, Churinababi, Huacal, Pinal and a great number of others.

The most celebrated modern localities are Arivaca, (also anciently famous as *Aribac*), Sopori, the Arizona mountains, the Santa Rita range, the Cerro Colorado, the entire vicinity of Tubac, the Del Ajo, or Arizona copper mine, the Gadsonia copper mine, and the Gila river copper mines. As late as 1820, the *Mina cobre de la Plata*, (silver and copper mines,) near Fort Webster, north of the Gila, were worked to great advantage; and so rich was the ore that it paid for transportation on mule-back, more than a thousand miles, to the city of Mexico.

The silver mining region of Arizona is, in fact, the north-western extension of the great silver region of Mexico. The mountain ranges are the prolongations of those which southward in Sonora, Chihuahua, and Durango, have yielded silver by millions for centuries past. The general direction of the mountains and the veins, is north-west and south-east, and there are numerous parallel chains or ranges which form long and narrow valleys in the same direction. Like most mineral regions, Arizona is of small value for agriculture, possessing in comparison with its extent but little arable land, and in many parts is nearly destitute of water, and desert-like. Much of this forbidding and arid surface would, however, prove fertile if irrigated.

In March, 1856, several gentlemen who had spent several years in Sonora and the Gadsden Purchase, formed an association in Cincinnati, Ohio, for the purpose of sending out a small party to secure by purchase or discovery one or more of the old deserted mining ranches. Col. Chas. D. Poston, of Kentucky, with Mr. Ehrenburg and Mr. Frederick Brunckow, and a party of frontiersmen, were fitted out, and after several months of exploration, purchased the Arivaca ranche, near Tubac, and established the head-quarters of the company at the old mining town of Tubac, on the Santa Cruz river, and near the Santa Rita mountains and the northern spurs of the Arizona or Arizuma Range. This ranche, in addition to all its mineral wealth, contains twenty thousand acres of agricultural land, with permanent water, wood, and grass. It contains twenty-five silver mines, or openings, which were worked by the Mexicans previous to the Apache war, and became famous for their rich ores. The best known were Mina San José, Santa Margarita, Basura, Blanca, Arenias, Tajitos, Amado, and La Purissima. Titles were also acquired to many veins of silver ores in the Santa Rita mountains, among which were the old mines of Salero and Ojero.

Seven miles north-east of the Arivaca ranche, on the Cerro Colorado, other interesting and important mining localities were found, among which were the Heintzelman, Mina Carlos, Maria Cesario, Puertozito, Guadalupe, Amarillo, and Mina Longorenia. These results led to the permanent organization of the company known as the Sonora Exploring and Mining Company, of which Major S. P. Heintzelman, of the United States Army, who was several years stationed at Fort Yuma, was elect-

ed President. As the Heintzelman vein, which had been discovered by the party, afforded some very rich specimens of silver ore, attention was specially directed to it, and it was soon found expedient to concentrate all the labor there, and to temporarily suspend operations in the Santa Rita and Cajetano mountains. In August, 1857, the vein had been opened to a depth of fifty feet, and a pile of ore estimated by assay to be worth twenty thousand dollars for the silver, thrown out. The Salero mine was opened and cleared to a depth of eighty feet, and silver-bearing galena was being extracted in quantity from the Arenias mine. Samples of the ore from the Heintzelman, which were sent to New York and San Francisco for assay, gave results confirming those of the mineralogists and metallurgists at the mine. Prof. John Torrey, of the United States Assay office, found silver in the ratio of 237 ounces to the ton of 2,000 lbs., and 33 per cent. of copper. The combined results are given in the following table:

ASSAYS OF SILVER ORES FROM HEINTZELMAN MINE.

	Grains per lb. Av.	*Value per lb. Av.*	*Value per ton.*
Assays by Prof. Booth........	247.80	$0.67	$1,342 00
" "	87.64	0.2375	475 00
" Prof. Torrey......	51.99	0.16	322 94
" " Locke.......	79.10	0.2150	428 46
" E. Kinsey.........	239.40	0.6483	1,296 60
" "	525.00	1.4218	2,843 60
" Min. Eng. at Tubac.	345.33	0.9350	1,870 40
" " " "	520.00	1.4075	2,816 60
Total 8 Assays........	2096.26	$5.6913	$11,395 60
Average..............	262.03	0.7114	1,424 45

Assays of selected portions of the ore have given much higher results, even $20,000 worth of silver to the ton of ore. Recent assays of samples, by Dr. Jackson of Boston, showed the presence of from thirteen to sixteen per cent. of silver, and thirty-seven to thirty-eight per cent. of copper. He regards the ore as *Stromeyerite*, or sulphuret of silver and copper. Many of the specimens from the mine consist of a mixture of vitreous copper (sulphuret) and argentiferous minerals, the external characters of which are not well defined. Mr. Brunckow recently reports finding some very fine specimens of iodid and bromid of silver, and a silver amalgam. Native

or *virgin* silver, is also reported to exist in the vein. Twenty-two tons of ore sent to San Francisco and smelted in a reverberatory furnace yielded $450 a ton, but it was found that a large part of the silver had been lost in the furnace and residues; this, with other experiments, led to the adoption of the barrel amalgamating process for the greater part of the ores, while some were best adapted for smelting, and the poorer and clayey portions for the primitive and simple *patio* process as followed in Mexico. After many delays, from the difficulty of transportation and erection of the requisite machinery in that isolated region, two barrels have been set in motion, each capable of receiving 1060 lbs. of ore. The last reports of Mr. Kustel, superintending the amalgamation-works, under date of May, 1859, state that 35 tons of the ore yielded $5189 53 in silver, or an average of $148 to the ton. A part of this ore, 6 tons, was very poor, and best adapted to the *patio* process.

Mr. Ehrenberg explains this result, and makes the following estimate of the general or average richness of the ore, based upon the results obtained from the commencement of reduction of the ore, at the mine and elsewhere.

"According to the estimate of Mr. Lathrop, and the different engineers, the ore brought to the surface from the Heintzelman vein, amounted in quantity to 225 tons. I assume this to be correct, but think it low, but have based on it the following calculations. It was and is distributed as follows, and yielded in silver the amounts noted :

	Tons.	*Yield.*	*Total value.*
1. Shipped to San Francisco	22	$450 00	$9,900 00
2. Smelted at Cerro Colorado	7	900 00	6,300 00
3. Ore stolen and sold in Sonora, at least	11	900 00	9,900 00
4. Middling and poor ore amalgamated	35	148 00	5,180 00
5. On hand yet	150	150 00	22,500 00
Total,	225		$53,780 00

"Which gives an average of $238 13 per ton of ore. This result, however, is not quite correct, as the ore sent to San Francisco was reduced by parties who had neither knowledge or material to do it properly. They themselves allowed that nearly $5000 in silver was still in the bottom of the furnace, the slag, and some other unknown places, of which we were to get 75 per cent. The ores shipped to them were first

selected as the richest to produce a large working capital soon. All subsequent selections could not have been better, and still the latter yield at our own furnace at Cerro Colorado, $900 00 per ton. It is then but fair to assume this, at least, of equal value. Corrected thus it stands as follows : "

	Tons.	*Yield.*	*Total value.*
1. Smelted at San Francisco	22	$900 00	$19,800 00
2. " " Cerro Colorado. . . .	7	900 00	6,300 00
3. Ore stolen and sold in Sonora . . .	11	900 00	9,900 00
4. Amalgamated in Arivaca	35	148 00	5,180 00
5. Ore from which No's. 1, 2, and 3, were picked and now on hand . .	150	150 00	22,500 00
Total	225		$63,680 00

True average then per ton ore, $283 02.

The first bar of silver from these works, was produced in March of this year, since which many of different values have been sent in or found their way to the mints through the channels of trade. The largest bar yet made, weighed about 930 ounces, amounting in value, at $1 28 the ounce, to twelve hundred dollars. At the last accounts from the mine, two of the barrels, worked four days in the week, yield about 1200 ounces of silver, and the smelting furnace some 300 or 400 ounces more.

According to Mr. Brunckow, the vein traverses strata of metamorphic clay slate obliquely, and has well defined walls. The engine shaft is now 100 feet deep, and a cross-cut at 60 feet from the surface, showed the vein to have a width of from three to five feet ; above, on the 30 foot level, the width is from two to three feet.

The motive power at the amalgamation works is insufficient, and good results cannot be obtained with the barrel process without regularity of motion, which it is difficult or impossible to have with mules. There is besides, much injury and loss occasioned by stopping to rest or change the animals. Arrangements for erecting steam engines, and additional barrel machinery have been made, and the mining operations will be vigorously prosecuted.

SANTA RITA SILVER MINING COMPANY.

This company was organized in 1858, to work several of the veins of silver ore in the Santa Rita mountains, discov-

ered by the exploring parties of the Sonora Exploring and Mining Company. These veins and mines include the Salero and Ojero, Asugarero, Bustillo, and others east of the Santa Cruz river. Some of these mines were worked long ago, and large amounts of silver taken out. The Salero is a vein of some three feet in width, and an old shaft has been cleared to a depth of 80 feet without reaching the bottom. The Ojero was a mine of great reputation among the Mexicans, and was abandoned on account of the caving in of one of the walls. The Bustillo was opened more recently than either of the others, and has been mined only twenty-five or thirty feet. The ores from these mines are chiefly argentiferous galena, and are best adapted to smelting or mingling with other ores. The pine forests of the Santa Rita mountains are visible from the mines, and will afford lumber and fuel. One of the veins has been traced by old workings, for a quarter of a mile.

PATAGONIA, COMPADRE, AND OTHER MINES.

The Patagonia vein near Fort Buchanan, is composed chiefly of argentiferous galena, yielding from forty to eighty ounces of silver to the ton of ore. It exists in considerable quantity, and is easily mined and smelted. The locality is being prospected and worked under the direction of Captain Elwell and Mr. Brevort.

The Compadre and French mines are now being worked, under the direction of Col. Titus and company. Furnaces for melting are being erected about ten miles from the fort.

Of the operations upon these mines, and several others now being prospected in the territory, there is as yet but little information. Much labor and time in that new and remote region is necessary to prepare for systematic working, and to develope the extent and character of the different veins even upon and near the surface.

STEPHENSON MINE.

One of the oldest and best known mines within the limits of the proposed territory, is that in the Organ mountains, about fifteen miles from Fort Fillmore, on the Rio Grande, generally known in the States as the Stephenson mine. It has yielded large amounts of silver, but has not been worked

for two or three years. The ore is an argentiferous galena, with small quantities of copper pyrites, which in all probability is auriferous, as gold is found in the silver extracted from the ore. The mine has been worked very rudely in the primitive Mexican style, and the ore was taken to the banks of the Rio Grande to be smelted. It was melted on a rudely constructed hearth, and the lead oxydized by a blast of air from blacksmiths' bellows worked by mule power. The ore yields from 40 to 100 ounces of silver to the ton, and is found in great abundance. A part or the whole of the lead in this ore might be saved by adopting other processes for extracting the silver. It is believed also, that in the form of pig-lead with the silver combined, it would bear the cost of transportation to New York where the separation could be more economically effected. The ore is also valuable in Arizona to mix with other ores poor in lead, which require smelting to obtain the silver. A company—The Fort Fillmore Mining Co.—has recently been formed in New York to work this mine on an extended scale.

It is hardly necessary to refer to the extreme richness of the mines of silver in the south-eastern prolongation of the Arizona mountains into Sonora. Both Ward and Wilson, in their valuable works upon Mexico, have given a mass of the most important statistics upon these mines and their extraordinary richness. Of Sonora, Wilson states that it is "a region of country which combines the rare attractions of the richest silver mines in the world, lying in the midst of the finest agricultural districts, and where the climate is as attractive as the mineral riches. But its richest mineral district is near its northern frontier, and is almost inaccessible, and can never be advantageously worked without an abundant supply of mineral coal for smelting; nor can any of its mines or estates be successfully worked without greater security for life and property than at present exists. The capitalists of Mexico will not invest their means in developing the resources of Sonora, and in consequence, the finest country in the world is fast receding to a state of nature." He gives "the following record in evidence of the masses of silver extracted at Arizuma. Don Domingo Asmendi, paid duties on a piece of virgin silver, which weighed 275 pounds. The king's attorney brought suit for the duties on several other pieces which together weighed 4033 pounds. Also for the recovery, as a curiosity, and

therefore the property of the king, of a certain piece of silver of the weight of 2700 pounds. This is probably the largest piece of silver ever found in the world, and yet it was discovered only a few miles distant from the contemplated track of our Pacific Railroad."

COPPER LOCALITIES AND MINES.

Copper ores of the richest description are known to abound in Arizona. When the overland emigration to California by the Gila route commenced, the emigrants frequently brought in masses of rich ore which they had picked up along the road. These specimens were chiefly native copper, very pure, invested with a crust of red oxyd of copper and of green carbonate, the whole yielding by assay about 90 per cent. of copper. It was for a long time believed by some that this ore contained a large percentage of gold, a fallacy which was dissipated by a thorough and expensive trial. One of the most important localities of this ore is in the Sierra del Ajo, 135 miles west of Tubac, where the red oxyde and green carbonate occur in large quantities, and have long been in use by the Indians for painting their bodies.

A company—the Arizona Copper Mining Company—has been formed to work these mines, and at an expense, it is said, of over $100,000 have supplied their mines with an abundance of water, erected buildings, smelting furnaces, and raised over a thousand tons of ore, a part of which was shipped to England and sold there to great advantage. It costs, delivered at Swansea, $125 a ton, and is worth from $200 to $375 per ton. The mines are one hundred and thirty miles from the mouth of the Gila River and about sixty miles south of it.

Another locality of rich copper ore varying from 30 to 70 per cent. is immediately upon the Gila river, and only twenty-five miles from its mouth. The ores can be loaded from the mine directly into flat boats and transported down the Colorado river, to the Gulf of California, where they may be transshipped to England or to the Atlantic ports.

The Mimbres Copper Mine, is another important locality, and is regarded as one of the richest yet opened in the Territory. About two hundred men are now employed in working it, and the copper is sent to the mint at Chihuahua, and to the Atlantic States. Mr. Brunckow, the mineralogist of the Sonora

Exploring and Mining Company, who has visited the place, followed the vein about eight miles northward and did not find any indications of its disappearing. It is associated with silver ore, and iron ore is found in abundance in the vicinity.

Lieut. Mowry makes the following statement respecting the agricultural resources of the Territory :—" The agricultural resources of Arizona are sufficient to sustain a large mining population, and afford abundant supplies for the great immigration which will follow the development of its mineral resources. The whole valley of the Gila, more than four hundred miles in length, can be made, with proper exertion, to yield plentiful crops. The Pimos Indians who live in villages on the Gila, one hundred and seventy miles from its mouth, raise large crops of cotton, wheat, and corn, and have for years supplied the thousands of emigrants who traverse the territory en route to California. These Indians manufacture the cotton into blankets of fine texture and beautiful pattern, which command a high price. They also grind their corn and wheat and make bread. In fact the Pimos realize in their every-day life something of our ideas of Aztec civilization. A town will probably grow up just above the Pimos villages, as there is a rich back country, and the streams afford valuable water power for running mills."

Notwithstanding the amount of information already gained of the mineral riches of Arizona, it is evident, from a moment's consideration, that our knowledge of the number and extent of veins and localities of both silver and copper is extremely limited. The country has never yet been systematically explored for minerals, and large portions of it are completely unknown to us. Except along the lines of travel and the routes of the surveys for a railroad route the country is, for the time, almost inaccessible, and must of necessity remain unexplored, in detail, until strong parties are organized for the purpose. The developments already made, great as they are, may be regarded as indications, merely, of what may be expected when geological and mineralogical explorations are pushed forward with energy into the cañons of the Sierras, and capital and skill follow to seize upon and develop the many valuable mineral localities which will inevitably be discovered. Until now, the Anglo-American mind has scarcely been directed to the systematic and thorough working of silver mines and the metallurgical treatment of the ores ; and we may rea-

sonably look for great improvements in both departments, whereby the cost of producing silver will be greatly lessened, and permit even the poorest ores to be advantageously worked.

Silver mining in Arizona possesses some great natural advantages over silver mining in Central Mexico, where that business has been mostly carried on. Many of the mines in that part of Mexico are in the midst of lofty mountains, hundreds of miles from the sea-coast; only to be approached on the backs of mules, by almost inaccessible paths, or over roads constructed at immense expense, thus greatly enhancing the cost of supplies. Heretofore, the expense of transportation to the mines of Arizona has also been so great as to seriously retard their development. A desert without water intervenes a part of the way between Tubac and the coast of California, so that freight from San Francisco to the mines has in some instances amounted to hundreds of dollars to the ton. This has been imperious from the political, not *geographical* position of the country, for a good wagon road connects Tubac with the Mexican port of Guyamas, 325 miles distant. Lobos, in Sonora, it is expected, will eventually become the seaport of the mining region of Arizona, from whence it is distant but 175 miles, over a level country, with good pasturage.

By the laws of Mexico, the transportation of *machinery* through its territories is free. The basis of a treaty is now preparing between the agents of the Mexican and American governments, which is to permit the free transit of merchandise across the State of Sonora to Arizona. This treaty will probably be soon completed, and a new impulse thereby given to mining operations, in the comparatively low cost of transportation; Guyamas and Lobos each being of easy and cheap access, by water, from San Francisco and New York—the latter place via the Isthmus of Panama.

The establishment of the great semi-weekly overland mail between St. Louis and San Francisco, greatly increased the facility of access to this interesting region, and continues to afford regular communication with the Atlantic cities and San Francisco on the Pacific. The route traverses the entire length of the Territory from east to west, placing it within 16 days of St. Louis and 7 of San Francisco. But the wealth and latent prosperity of this and adjoining regions demand more than this—the long-talked-of Pacific railroad must be built—the apathy of the American people on this subject

must give way before that necessity which the events of every month render more apparent. It requires no prophet to foretell that Arizona is to become the great field of American mining enterprise, and as famous for its silver and copper as California for its gold.

A sanguine calculator estimates the future annual yield of Arizona in silver, at one hundred millions of dollars. Mexico, the great silver-bearing country of the world, has never yet exceeded an annual yield of thirty-five millions: it is not therefore probable that the dream of this Arizonian visionary will soon be verified. But when we perceive with what rapidity our population, in its advance to the Pacific, spreads over new territories—the energy with which it overcomes untold obstacles—the avidity it shows in launching upon novel enterprises, be they but promising—it is not perhaps too much to look for an honest measure of prosperity to that long, narrow strip of mineral bearing territory, purchased by Mr. Gadsden for us, of our Mexican neighbors, as a route for a railroad to the Pacific; which in a spirit of anticipation has already received the dazzling appellation of the "SILVER STATE OF ARIZONA."

DISTANCES TO PROMINENT POINTS IN THE TERRITORY AND SONORA.

The two principal towns in the mining regions are Tucson and Tubac—the first on the line of the overland mail route; the latter 52 miles south of it, and each containing a few hundred inhabitants. Tubac is the head-quarters of the Sonora Exploring and Santa Rita Silver Mining Companies. From Tubac to points of interest in the vicinity, the distances are as follows:—Heintzelman Silver Mine, at Cerro Colorado, 22 miles, six miles south of which on the Arivaca Ranche are the amalgamation works of this mine. Santa Rita Silver mines, 10 miles; Tumacacari Ranche, 3 miles; Sopori Silver mine and Ranche, 11 miles; Calabazas Ranche, 15 miles; Fort Buchanan, (garrisoned by United States troops) 40 miles; San Xavier Silver mine, 35 miles; Patagonia Silver mine, 48 miles; Ajo Copper mine, 135 miles. Distances from Tubac to prominent points out of the Territory, by the travelled routes, are as follows:—San Francisco, 1074 miles; San Diego, 510 miles; Fort Yuma, (built by Major S. P. Heint-

zelman, U. S. A. in 1851,) 330 miles; El Paso, 389 miles; Saint Louis, 1770 miles. Towns in Sonora, Mexico—Santa Cruz, 54 miles; Magdalena, 51 miles; Altar, 95 miles; Hermosillo, capital of Sonora, 229 miles; Guyamas, port of entry of Sonora, 329 miles; Lobos, on the Gulf of California, 175 miles.

LIST OF MINING COMPANIES IN ARIZONA AND VICINITY.

Four of the mining companies in Arizona are incorporated under charters from different States. *The Sonora Exploring and Mining Company* was organized in 1856, under the laws of Ohio; capital, two millions of dollars; office of the Company, No. 88 Wall Street, New York. *Directors,* Samuel Colt, Hartford, Conn.; Wm. T. Coleman, New York City; Chas. D. Poston, Elizabethtown, Ky.; Augustus Belknap, New York City; W. M. B. Hartley, Hartford, Conn.; Chas. S. Brown, Boston, Mass.; Henry Howe, Cincinnati, Ohio. *Officers,* Samuel Colt, President; Wm. T. Coleman, Vice President; Chas. D. Poston, Acting Sec'y; S. H. Lathrop, Director of mines; Richard W. H. Jarvis, Treasurer at the mines; Guido Kustel, Frederick Brunckow and T. Methner, Mining Engineers. Head-quarters, Tubac, Arizona; Mines near Cerro Colorado, Arizona; Reduction Works, Arivaca, Arizona. S. H. Lathrop, Director. Capital, $2,000,000, in 20,000 shares of $100 each. First silver ore reduced in July, 1858. Number of Mexican Peons employed, 140.

The *Santa Rita Silver Mining Company* was organized in the year 1858, under the laws of Ohio; capital one million of dollars; office, 167 Walnut Street, Cincinnati, Ohio. *Directors,* Dr. Geo. Mendenhall, Cincinnati; Thos. Wrightson, Cin.; Thos. H. C. Allen, Cin.; John D. Park, Cin.; Chas. D. Poston, Elizabethtown, Ky.; Jas. O'Kane, Columbus, Ohio. *Officers,* Dr. Geo. Mendenhall, President; Thos. H. C. Allen, Vice President; Thos. Wrightson, Secretary; Wm. Wrightson, Director at the mines. Head-quarters, Mission of Tumacacari, Arizona; mines, Santa Rita Mountains, Arizona. Wm. Wrightson, Director. Capital, $1,000,000, in 10,000 shares of $100 each. Number of Mexican Peons employed, 90. First silver ore reduced May 7th, 1859.

The *Sopori Land and Mining Co.,* and the *Arizona Land and Mining Co.* were organized in June, 1859, at Providence, R. Island.

Fort Fillmore (Stephenson) Silver Mining Co., at Fort Fillmore, New Mexico. Organized December, 1858. Major Jno. I. Sprague, U. S. A., President. Office, No. 34 Pine Street, New York. Mines in Organ mts., near Rio Grande. W. H. Rittler, Director and Engineer. Capital $1,000,000, divided in 50,000 shares of $20 each.

Sopori Mining Co. Organized August, 1858. Office, Providence, Rhode Island. Mines and land in Arizona. Welcome B. Sayles, Director. Capital $1,000,000, divided in $10,000 shares of $100 each.

"*Setentrion Mines.*" Organized as American and Mexican Mining Company, in June, 1859. President, George Davis. Office 34 Pine Street, New York. Capital $2,000,000, divided in 100,000 shares of $20 each. Mines located in Chihuahua.

Mexican Pacific Mining Co. Organized by charter from Pennsylvania, June, 1857, by E. L. Plumb. President, Geo. F. Allen. Office 92 William Street, New York. Capital $4,000,000, divided in 40,000 shares of $100 each.

Patagonia Mining Co. Private Association. Working mines near Sonoita River, Arizona. President, Capt. R. S. Ewell, U. S. A.

Union Mining Company. Working mines near the Sonoita River, Arizona, under direction of Col. Titus.

Boundary Mining Co. Private Company. Working mines near the boundary line of Sonora.

Arizona Copper Mining Co. Organized in 1854, in San Francisco, California, by Edward E. Dunbar. President, Major Robert Allen, U. S. A. Capital $1,000,000, divided in 10,000 shares of $100 each.

San Xavier Mining Co. Organized in San Francisco, in 1857. Mine near Tucson, Arizona.

Cahuabia Mining Co. A private company, working silver mines in the Papagueria, Arizona. President, Herman Ehrenberg. Director, William Brown.

Art. II.—PROCESSES FOR THE EXTRACTION OF SILVER, FOLLOWED AT THE REDUCING ESTABLISHMENTS OF THE HEINTZELMAN MINES, ARIZONA, AND THE REAL DEL MONTE MINES, MEXICO.

(*Compiled for the Mining Magazine.*)

The processes now in use at the Reduction Works of the Sonora Exploring and Mining Company, for the extraction of silver from the ores, are essentially three, viz: smelting, amalgamation in barrels, and amalgamation in the open air, or the *patio* process. They are briefly described by Mr. Frederick Brunckow, who has recently returned from Arizona, in a report to a committee of the stockholders, from which the following is in part extracted :—

"The ores of the Heintzelman vein, as well as most of the Mexican ores, contain a considerable portion of quartz, which renders them difficult to smelt. The richest portions only are therefore selected for the smelting process.

"The lower part of the furnace is built of a fine-grained refractory quartzose sandstone, found in the neighborhood. The upper part and the smelting house are built of brick, dried in the sun and air, called *adobes.* The smelting chamber inside the furnace is twelve inches square, and the blast is produced by a double bellows constructed at the place and worked by one man.

"To each part of selected silver ore, three parts of lead ore from the Arenilla mines are added, and after complete fusion the contents of the chamber are allowed to run off into a basin on the outside. As it cools, a crust is formed on the surface, which contains to a large extent sulphurets of copper, lead, and the impurities. This is taken off from the lead below and kept separate. The lead is run into castings in the form of cakes, ten inches in diameter, weighing 75 pounds. Six of these lead cakes are put on edge, one near the other, upon two inclined iron plates, which nearly touch each other. Charcoal is placed around and between the cakes, so that they are enveloped, and after kindling it the lead cakes must be protected from draughts of air. The heated cakes commence to melt and sink, and the lead runs down the iron plates to a basin, from which it is run into pigs. This lead is free from copper,

and yields about forty pounds of silver to the ton. A skeleton of each lead cake is left behind on the iron plates, and is rich in copper, and yields some silver. In order to separate this from the copper, the skeleton is broken into fragments and passed the furnace in company with the crusts taken from the lead in the first place, and with some other lead ore. By smelting the skeletons and crusts, which contain sulphurets, etc., lead will result, which is put in castings in the form of cakes; these cakes are put again upon the declining plates, and pass through the process described before. The remaining skeletons this time contain very little silver; they are smelted in a copper refining reverberatory furnace and refined, and in the form of balls of metallic copper are delivered over to the amalgamation works, where they are required for the barrel process.

The argentiferous lead, free from copper, is put in a cupellation furnace, and passes the well-known oxydating process; the silver remains and is refined. The resulting oxyd of lead is added to the lead and silver ore, and again passes the blast furnace.

THE BARREL AMALGAMATING PROCESS OF REDUCING SILVER ORE.

To prepare the ore for amalgamating in barrels, it is crushed by stamps, and passes three sieves. The siftings of the first sieve are put under the stamps again. The sifting of the second sieve is as fine as the grain of wheat, and the total sifting is delivered to the ore-mill, Arastra, where it is ground with water, to a very fine powder; then it is dried and crushed. The sifting of the third sieve gives a powder fine as flour. This powder and the obtained fine-ore powder of the arastra mill is mixed with 8 per cent. common salt, put in a reverberatory roasting furnace, and roasted till all the metals are formed into chlorides; this process is completed in five hours. Eight hundred pounds of this powder are put into the amalgamation barrel, together with a certain quantity of water and 75 pounds of the copper balls from the smelting furnaces. The barrels are then made to revolve, so that the whole mass in the barrel will form, after a certain time, a paste so stiff that the 400 pounds of quicksilver now added, will not remain in a separate mass at the bottom, but

will be divided through the whole body of ground ore in minute globules, unseen by the naked eye. The barrels are now made to revolve for 22 hours. The formed chloride of silver will be precipitated into metallic silver by the presence of the metallic copper; chloride of copper will be formed, and this will be lost. The silver in the metallic state in contact with the quicksilver then forms the amalgam. The copper exists in the roasted mass as chloride of copper; it has no influence in the amalgamation process, and is lost in the residue. After 22 hours, more water is put in the barrels, in order to thin the paste, and to accumulate the minute globules of quicksilver and the formed amalgam in a mass. This will be accomplished in two hours, by allowing the barrels to revolve slowly. The barrels are now opened, and the quicksilver and amalgam runs out in troughs, from whence it is put into strong canvas bags. The surplus quicksilver is pressed through the bags by its own weight, the remaining stiff amalgam is retorted, the silver, not being volatile, remains, and is melted, and cast into bars. The bars are marked with the Company's stamps, numbered, their fineness according to the assay, and their value in dollars marked upon them.

THE PATIO AMALGAMATING PROCESS.

In different places in Mexico the method of amalgamation called the Patio process, is employed. This method of amalgamating differs entirely from the one just described, and can only be successful with a certain class of ore. The ore is crushed and ground to a very fine powder in the arastra mill, and without first roasting, mixed with salt, moistened, and piled up on a floor in equal piles. This floor, or *patio*, in Mexico is generally a large inclosure walled in and paved with blocks of stone. The piles of ore are formed in circles about forty feet in diameter, and are generally from a few inches to a foot in depth. Mules or horses are then driven violently around, and on the heap, until the salt and the powdered ore are thorougly commingled. The whole is then allowed to remain for several hours, when a portion of copper or iron pyrites, called *magistral*, is added and thoroughly mixed with the mass, by mules, as before. This magistral serves to effect chemical changes in the ore, and must be added in different proportions, according to the quality of the ore and the temperature.

Quicksilver is then added, and the mass kneaded and stirred by the treading of mules, they being urged forward around the circle by a man standing in the centre of the heap. This is repeated from day to day, with additions of mercury, and the complete decomposition of the ore, and the amalgamation, is generally effected in the warm season in the course of two or three weeks, in the cold season much longer. The mixture is then transferred to a tub or vat, where the amalgam is separated from the earthy residues and impurities by washing. The excess of quicksilver is strained off; the amalgam is formed into cakes, retorted, and the resulting silver cast into bars.

It is estimated that to reduce 10 tons of ore, each twenty-four hours, at the Heintzelman mine, fifteen stamps, two arastras and twelve barrels will be required, seven tons of the ore being amalgamated in the barrels, and three by the patio process. The condition of the works in May last, owing to insufficiency of power, mules alone being used, did not permit the reduction of more than four tons a week. Three barrels were in operation part of the time in May. These were capable of receiving 1,060 lbs. of roasted and prepared ore, which is equal to 1,100 lbs. unground ore, the loss in weight being due, in part, to mechanical loss in stamping and manipulating and to calcination. The consumption of wood is one and a quarter to one and a half cords to every ton of ore. To decompose the chloride of copper which remains after amalgamation, from three to four per cent. of the weight of the ore is required. Eleven barrels, yielding 119 pounds of silver, showed a loss of 59 pounds of quicksilver. This is four ounces to the marc of silver. Much better results may be expected when steam power is substituted for mules.

OPERATIONS AT THE REDUCTION ESTABLISHMENT OF THE REAL DEL MONTE COMPANY, MEXICO.

The following data are from a Report made by Mr. Buchan, the manager of the Real del Monte Company, in 1854, and the notes of Mr. E. L. Plumb, taken while on a visit to the mines in 1857. In a letter to Col. Poston, accompanying the statistics, Mr. Plumb observes :—

"They show what cannot usually be easily got at—the cost in detail of the actual working operation (so far as the reduction of ores is concerned) of a large Company.

"The Real del Monte Company is one of the most important mining companies in Mexico, and is under excellent management, as can well be inferred from the system with which every branch of expenditure is looked after. Nothing more reliable, or based upon a larger experience, can be had anywhere. Their ores, I may also say, are of the hardest and most refractory character. You will perceive, however, that they are not losing money."

The mean cost of producing 3000 pounds of silver ore at the Real del Monte Company's establishment, and the comparative economy of the different establishments of Sanchez, Velasco, San Miguel, and Regla, for the year 1854, is shown in the following table :

TABLE SHOWING PRODUCE OF SILVER AND COST OF EXTRACTION AT THE ESTABLISHMENT OF REAL DEL MONTE COMPANY.

At Sanchez, Velasco, or San Miguel, the Barrel Process is used: at Regla the Patio Amalgamation and Smelting.	*By Barrel Amalgamation at*			By Patio Amalgamat'n at Regla.	By Smelting at Regla.
	Sanchez.	Velasco.	San Mig.		
Stamping, mostly for labor,	$00 64	$00 59	$00 60	$00 26	$00 30
Wear of Stamp heads,	24	25	88	28	28
Grinding in Arastras, labor mostly,	78	70	08	83	....
Drying and lifting, mostly labor,	1 30	1 20	1 02	....	....
Calcination, mostly labor, (fuel below,)	2 15	1 76	1 57	....	....
Amalgamation in Barrels and Patio, mostly labor,	1 41	1 04	88	3 98	....
Smelting in furnaces, mostly labor, (fuel below,)	....	....	....	....	17 80
Wear of Barrels,	35	30	21	....	....
Distilling Amalgams, casting Silver into bars	08	10	07	05	04
Repair of Machinery, Furnaces, &c.,	33	60	50	48	3 90
Sundry costs,	55	30	40	40	3 40
Fuel, Wood,	3 79	3 31	4 27	....	1 00
Fuel, Charcoal,	31	30	27	20	34 90
Salt,	6 70	5 87	6 60	3 64	....
Sulphate of Copper,	....	....	....	2 13	....
Litharge,	....	....	....	....	21 50
Tallow and Oil, for Machinery,	33	37	29	10	....
Quicksilver	2 15	2 39	1 58	4 32	....
Steam Power, mostly fuel,	1 91	4 23	....	....	....
Animal Power, mostly forage,	2 14	....	....	....	....
Salaries, Expenses of Management, assaying, &c.,	1 31	1 14	1 03	1 09	6 80
Total cost of reducing 3000 lbs. of Ore,	$26 47	$23 95	$20 25	$17 76	$89 92
Mean produce of Silver per each 3000 lbs. of Ore,	92.88	94.80	62.40	65.92	518.40
No. of Cargas (of 300 lbs. each) of Ore reduced in 1854,	48.310	53.895	49.184	37.982	2.386
Ounces of Quicksilver lost per each $8 00 of Silver produced,	4.79	4.97	5.28	12.71	

The following may be taken as the average yield of ores from the Company's mines :—Rosario mine, $13\frac{1}{2}$ marcs ($8 00 each) of silver per monton (3000 lbs.) of ore ; San Patricio mine 9.2 marcs per monton ; poor and refractory ores, from the Santa Brigada and Santa Inez, $7\frac{1}{4}$ marcs per monton.

Average yield of all ores reduced in 1849 to 1854, 9 75-100 marcs per monton.

Total amount reduced by the Company in 1849 to 1854, inclusive, 684,845 cargas, (of 300 lbs. each,) or 97,835 tons, producing \$5,858,330, or 5,352,600 ounces, *being 54½ ounces* to the ton of ore.

The amount of silver left unextracted by the several processes is as follows: Smelting, 6 per cent.; Patio amalgamation, 15 per cent.; at Velasco, by best barrel processes, 16½ per cent.; and on the average of the three Haciendas engaged on this process, (barrel,) 19 to 20 per cent.

The salt used by this Company is brought from San Luis by a land carriage of three hundred miles, at a freight of \$42 per ton, and from Campeachy by shipping to Tampico and Tuspan. By either route it costs \$84 per ton. 1700 tons are annually required by this company.

The consumption of wood in 1854 was 60,000 tons, or 450,000 cargas. The Company's expenditure for fuel is at least \$150,000 per annum. All of it is brought a considerable distance on mules.

Mr. Buchan states, in his Report, (1854,) that "thirty stamp heads, fifty to eighty strokes per minute, can grind of our quartz ores 100 tons per week, to an exceedingly fine sand. To effect our annual grinding of 25,000 tons, not less than 60 tons of cast iron is worn away."

The following is stated as the profits and yield in silver of the Real del Monte Company's mines:

May, 1849, to December, 1852, .	\$327,160
Year 1853, ...	582,328
" 1854, ...	696,443
Total produce, 1854, ...	1,811,882

In 1857 these mines were yielding to the Company \$60,000 per week in silver, or over \$3,000,000 per annum, of which over 50 per cent was net profit.

The engineer, in his Report to the Company at the close of the year 1857, says:

During the five years ending Dec. 31st, 1857, the Company's mines (four) produced in silver \$11,823,803. Yield in 1857 was \$3,039,616 00.

The same mines that are now worked by this Company have been worked more or less since an early period.

Their produce from 1759 to 1781 was . . .	$15,000,000
After death of 1st Conde de Regla to the Revolution, ...	10,000,000
While being worked by the English, ...	10,481,475

Art. III.—OBSERVATIONS ON THE MINERAL RESOURCES OF THE ROCKY MOUNTAIN CHAIN, NEAR SANTA FÉ, AND THE PROBABLE EXTENT SOUTHWARD OF THE ROCKY MOUNTAIN GOLD FIELD.*—By Wm. P. Blake.

As the discovery of gold in quantity in the western part of Kansas renders any information which may be given upon the mineral resources of the Rocky Mountain region particularly interesting at this time, I am induced to send to the Society a brief notice of some of the results of a tour of exploration made in 1857, in the mountains of the northern part of New Mexico, near Sante Fé.

The vast extent of country in New Mexico, which remains unexplored, precludes the possibility of presenting even a fair outline view of its mineral resources as a territory. The few facts which I offer must therefore be regarded only as an addition to what has already been discovered, and an indication of what yet remains to reward the labors of the diligent explorer.

First in interest at this time, as bearing upon the extent of the Rocky Mountain gold field, is the gold field of New Mexico, which has been known and worked since 1828. It is confined to the Placer or Gold Mountains, about twenty miles from Santa Fé, towards Albuquerque, and although worked continuously since its discovery, its limits have not been extended by exploration far from the place where the gold was first found. The yield of gold has been chiefly from the placers or washings, and not from veins, and was estimated by Wislizenus, in 1847, to vary from 30,000 to 250,000 dollars a year; but it soon after greatly diminished, until counted by hundreds rather than thousands.

I found these placers to be on the slopes of subordinate or outlying ridges of the eastern ranges of the Rocky Mountain chain, and to be true hill-deposits, affording coarse gold like

* From Proceedings Boston Soc. Nat. History, vii. p. 64. July, 1859.

that from the high placers of California. The "pay gravel" lies deep below the surface, from twenty to sixty, and even one hundred feet, and is generally very rich. Owing to the almost total absence of water, mining and washing have been but imperfectly conducted, and a large amount of gravel remains untouched. The Mexicans sink circular shafts, like wells, through the soil and alluvions to the gravel, then tunnel upon the bed-rock and take the good gravel to the surface in sacks, cart it two miles to water, and then pan out the gold in wooden bowls or *bateas.* In the winter, water is sometimes obtained by melting snow with heated stones. There are two principal placers, the "Old" and the "New," and at the former there is a small stream or rivulet for a part of the year. These placers are about five miles apart, but there has been very little prospecting to determine their real extent. New Placer is known to be about ten miles long, for the workings or pits have extended over that distance. The gold appears to have washed out of two cañons in the mountain, which are near together, and appear to drain but a very small part of the surface. Veins or beds, in the rocks, containing gold, outcrop higher up in the ravines of the mountain. It is remarkable that in one place, at least, gold occurs in strata of quartzose sandstone, probably of the age of the carboniferous, and in great ferruginous beds, rather than in veins. The sandstone appears to have been charged with auriferous pyrites, by the decomposition of which gold has been liberated. At other points regular quartz veins bearing gold and pyrites are found, and some of them have been worked at different times for over twenty years. The *Ortiz Mine* has been worked to a depth of one hundred and thirty-five feet, and levels driven for nearly two hundred yards on the course of the vein, which is represented to be about six feet thick. The Biggs' Mine, which adjoins it, has been worked to nearly the same depth. In the mountains known as *Los Cerillos,* about eight miles from New Placer, there is a deserted mine, known among the old Mexicans as *La Mina del Oro,* the true character of which could not be well determined. It certainly is very ancient, and there is no record or tradition concerning it, except that the work was done before the Insurrection, which took place in 1680. The principal shaft is over two hundred feet deep, and is cut vertically, with great precision, through solid rock. The sides are very smooth, and it is evidently the work of expe-

rienced miners. A stone, allowed to drop vertically, does not reach the bottom for several seconds, and then gives a dull sound as if striking earth, showing that there is no water in the mine even at that depth. There are two other shafts, and they all communicate by galleries in miners' style. In 1834, there was an attempt made to clean out the mine and work it, by a party of Mexican residents of Santa Fé, but without any success, there being no water at the mine or machinery for raising and reducing the ore.

At the placers, large lumps, pepites or nuggets, of gold have been frequently found; the largest, of which I could get reliable information, was worth about $2000, another was valued at $1800, and there have been many worth from fifty to eighty. At Old Placer, none larger than about eighty pennyweights had been found. The gold from New Placer is remarkably black and ill looking on the surface, but is very fine, being worth twenty dollars an ounce. Only sixteen dollars an ounce is paid for it to the Mexicans at the mines by the traders. When these miners are employed by the day they receive from sixty to seventy-five cents.

The Gold Mountains and Placers are about three hundred miles south of Pike's Peak, and there is little reason to doubt that gold will be found at intervals, if not in an almost continuous belt, over the entire distance. The New Mexican gold field is probably much more extensive than is generally supposed, and when it is thoroughly prospected, many rich placers will doubtless be found. The geological indications in the mountains north of Santa Fé, judging from specimens brought to me, are favorable to the presence of gold, and are more like the auriferous rocks of other gold regions than the formations at the Placer Mountains.

The observation of the occurrence of gold in beds of sandstone is not only interesting to science, but of considerable practical importance. The erosion, or breaking down of such a bed, would supply gold to a stream or deposit without its being accompanied at the same time by the usual beds of quartzose gravel, the soft friable sandstone being completely broken up into sand by attrition. Thus, rich deposits may exist on the hill-sides without any indication of their presence by beds of rolled gravel or broken fragments of veins on the surface. Mr. Green Russell, an experienced placer miner and mountaineer, who made an extended tour through the new

gold region of Western Kansas last year, informs me that he has observed such conditions ; having found rich deposits of gold without much gravel, and scarcely any quartz. From the same authority, I learn that gold occurs in considerable quantity upon the Arkansas River, in extremely thin scales, as low down as the crossing of the old Santa Fé road, near old Fort Atkinson. This is far out upon the broad plains, and below any coarse alluvions. The quantity of gold increases as the river is ascended, and the best prospects were obtained at the Pueblo above Bent's Fort. The Arkansas, near this point, has several forks or branches heading in the mountains to the southward, in the vicinity of the Spanish peaks, and there is much reason to believe that gold will be found there. A connecting link between the New Mexican gold field and that of Pike's Peak would thus be formed. A sample of the Arkansas River gold, brought in by Mr. Russell, yielded .971 by assay at the Dahlonega Branch Mint, being worth about twenty dollars an ounce, or nearly the same as the New Mexican gold. It would thus appear that the Rocky Mountain gold is superior in quality, the average of the California gold being from .875 to .885, and the Australian .960 to .966.

Next to the gold, but probably of greater importance to the country, is the existence in the Rocky Mountain chain of beds of coal of the carboniferous period, corresponding in kind to those of the great Apalachian coal field. Beds or layers of coal or lignite have at various times been reported to exist in the mountains ; but their age or character was unknown, but supposed to be of a period more modern than that of the true coal. I was able to determine by an abundance of fossils, that the true coal measures are developed there, having found not only shells but fossil ferns identical with species found in the coal measures of Missouri and Ohio. Seams of bituminous coal and thick beds of black shales occur only one mile from Santa Fé, and at other places in the vicinity, and I have no doubt that explorations would detect valuable beds at various points north and south along the whole Rocky Mountain chain through New Mexico and Kansas into Nebraska and beyond.

Twenty miles from Santa Fé, and not far from the gold mines, there is a bed of hard coal, specimens of which I examined and found to be true anthracite or debituminized coal, apparently equal in quality to the anthracites of Pennsylvania. The presence of beds of anthracite coal in the Rocky Mountains is of great national importance in many points of view. One of

the great questions in connection with the proposed construction of a railroad to the Pacific has been,—Where shall appropriate fuel be obtained? In these beds of anthracite coal we have a store of the most compact fuel known, at a point nearly midway between the Mississippi and the Pacific. Here, then, is one great reason for the construction of a central road to the Rocky Mountains near Santa Fé, coal not having been found, and probably not existing in workable beds, in the lower and porphyritic ranges of western Texas and southern New Mexico. Even if wood were abundant in the mountains (which it is not, except at great elevations,) the coal is much more accessible and desirable. It is valuable not only for railway purposes, but to the inhabitants of the region, and is specially important for mining and metallurgical operations.

There is great reason to believe that the Rocky Mountain chain is rich in silver ores in the form of argentiferous galena. Stevenson's mines, near Ft. Fillmore, have long been known, and are very rich. Although worked very irregularly, and the ores smelted in the rudest manner, large amounts of silver have been extracted, while the lead and copper which occur with the silver have been totally disregarded and thrown away. Similar ore is said to occur in the Sandia mountains, near Albuquerque, where there are very ancient but now deserted mines. In the group of mountains known as *Los Cerillos*, fifteen miles from Santa Fé, I examined two or three argentiferous veins, the principal minerals being galena and blende with copper and iron pyrites. These veins occur in a porphyritic rock and are very promising in their appearance. They have been worked upon slightly, and some of the excavations appear ancient. The Mexicans say they were made before the Conquest.

Of copper ores, there are several localities. Sulphuret of copper, with blue and green carbonates, occurs in the Placer mountains. Native copper and red oxyd of copper are found near Jemez, in the valley of the Rio Grande. The specimens from this locality are peculiarly rich and promising, and much resemble the red oxyd and native copper of Arizona, which occurs in such abundance.

Magnetic iron ore, exhibiting polarity very strongly, is abundant in the mountains near the gold mines, and at some future day may be profitably worked for iron and steel, as coal and limestone are abundant in the vicinity. Specular

iron is reported to exist in veins or beds, but whether it is abundant or not was not ascertained.

In addition to the useful metals and ores, there are many valuable minerals and gems. The much prized Chalchihuitl (chalchee-wee-tee) of the ancient Mexicans, held in the highest esteem by the Montezumas at the time of the Conquest by Cortez, was obtained in the mountains about ten miles from the gold placers. This stone is a variety of turquoise, and the locality is the only one known in America. At Fort Defiance, the Navajo Indians bring in rolled fragments of garnets, perfectly clear and transparent, and of a most beautiful color, fully equal if not superior to those from Bohemia. Some of them are very large, and of considerable value. Beautiful chrysolites have also been obtained there; several specimens were shown to me in Santa Fé. Diamonds have been reported, but as yet there is no good reason to credit the statement.

It will thus be seen that the mineral resources of the Rocky Mountain region are extensive, and of a character to render it in a great measure independent of distant sections of the country. Its rapid settlement and the explorations which must result from the great emigration to the newly discovered placers, will not fail to bring to light many new localities of valuable minerals, and thus hasten the organization of a new and powerful State.

ART. IV.—REMARKS ON METAMORPHISM OF ROCKS.—BY CHARLES T. JACKSON, M. D., ASSAYER TO THE STATE OF MASSACHUSETTS.

ALTHOUGH the words Metamorphism, and Metamorphic rocks, are in common use among geologists, and appear in nearly every geological and mining report, it is certain that our ideas as to the nature and origin of metamorphosis are not very well defined and understood.

Geologists mean by this term to designate those alterations which rocks have undergone since their original formation, but more especially the changes which sedimentary matter has experienced by igneous action.

Thus it is supposed that calcareous deposits originating

from the crumbled remains of shells and corals, were rendered crystalline by the agency of eruptive igneous rocks; and Von Buch imagined that, in the formation of Dolomite, the magnesia was raised in some unknown manner by sublimation, and combined with the carbonate of lime as a carbonate of magnesia. Now every chemical geologist who has investigated this theory, finds that it is radically defective; for not one of the magnesian salts, nor any form of magnesia, is capable of sublimation. However, this subject we will consider hereafter more in detail. I will therefore mention some of the other metamorphic rocks.

Argillaceous and micaceous sediments, the detritus and wash of decomposed granite, gneiss and mica-slate rocks, when deposited by water form a clayey sediment in regular layers or strata; and when there are variations in the force of the currents that bring down and distribute these deposits, there will be lines of bedding more or less distinctly marked by coarser or by finer materials. Were such deposits formed at the bottom of a sea or lake, and the whole bottom should be so raised by subterranean forces, as to bring the deposits to light we should find the materials as originally arranged by aqueous deposition, and like our common alluvial and tertiary unaltered deposits. Now it happens that we find crystalline strata, bearing all the proofs of aqueous deposition, not only in the structure and arrangement of the matters, but also in the occurrence of various aquatic organisms—both marine and fresh water shells, fishes and plants—and yet the rock has a more or less crystalline structure. This would be called a metamorphic rock.

Formerly, changes of the character here mentioned, were attributed to the intrusion of igneous rocks, such as trap, syenite, porphyry, or granite, and since both sedimentary limestones and slates were found altered, in the manner stated, at and to a considerable distance from the eruptive rock, it was supposed that heat emanating from the igneous rock, effected these changes. Every geologist who has been engaged in extensive surveys, and has given much attention to this subject, must have been sorely puzzled to explain the extent of the metamorphic action, supposed to originate from the influence of an insignificant dyke of trap rock. He could not fail to perceive that a small dyke of a few feet in width, even if incandescent at the moment of its eruption, could not have sensibly heated

the stratified rocks for many yards on each side of it; but still he observes the metamorphism extending to a great distance beyond the dyke, and to be as marked remote from it as near the point of contact. Again, when it is supposed that by the elevation of igneous rocks beneath an aqueous sediment, some thousand or more of feet in thickness, that the heat permeated the whole mass to the very surface, and melted the mineral matters so as to render them crystalline, he would naturally ask how is it that such an imperfect conductor could have transmitted the heat of the nether rocks to such an extent and so regularly? He knows that while one end of a brick is red-hot, he may hold the other end of it in his naked hand without being burnt, and hence he doubts the power of the heated nether rocks to metamorphose, by their heat alone, thick masses of sedimentary strata. So sand-stones, being very poor conductors of heat, could hardly have been metamorphosed to any great extent by its sole influence, and yet we find the sand-stones wonderfully changed to a considerable distance from their junctions with trap rocks, and we find them and the amygdoloids filled with a vast profusion of zeolitic minerals, which somehow were produced by the influence of the igneous rocks. Having for thirty years made the subject of the influence of igneous and aqueous rocks on each other a study, without in all instances being able to satisfy myself, as to the true theory of the changes observed, I was greatly pleased on receiving some new light on this matter, through the researches of M. Daubrée, of Frankfort, in France,* and T. S. Hunt, of the Geological Commision of Canada.†

It now appears by direct experiments, that many metamorphoses of rocks can be made, and several minerals can be produced, by the action of water heated under pressure, and that even crown glass, consisting of silicia, soda, and lime fused together, may be so decomposed as to produce crystals of quartz, wollastonite, and some other well-known minerals; and that obsidian, which we know to be a glass, formed by the fusion of feldspar by volcanic heat, can, by water heated to 400° centigrade, be reconverted into crystallized feldspar: that apophyllite may be dissolved in water heated under ten atmospheres pressure, and be re-crystallized from the cooling solution—and

* Observations sur le metamorphisme, par M. Daubrée, 1858; and Sources Thermales de Plombieres, etc.

† Geol. Survey of Canada. Report of Progress for 1857. Toronto, 1858.

by observations made at the hot springs of Plombieres, by M. Daubrée, it appears that the waters of these springs, not heated beyond 70° centigrade, have, in the course of time, and since the Roman baths were built, deposited many of the zeolites, such as apophillite and stilbite. He also discovered in those ancient works, crystals of diopside, and some other new silicates; and then by extending his observations to the formation of minerals at Monte Somma, he has shown that many of them, even anhydrous silicates, were probably produced by the action of water, heated under high pressure. He shows also, by experiments of a very important character, the origin of anthracite, as produced by heating pine wood in water, under pressure, to 400° c. He says :—

"Des fragments de bois de sapin se sont transformés en une masse noire, douée d'un vive éclat, d'une compacité parfait, qui, en un mot, a l'aspect d'une anthracite pure ; elle est assez dure pour qu'une point d'acier la raye difficilement."

He adds : "This kind of anthracite, although infusible, is entirely granulated in the form of regular globules of various dimensions ; from whence it results clearly that the substance has been fused in its formation. It gives no traces of volatile matters when calcined ; the woody matter has then arrived at its last degree of decomposition. This compact carbon burns with extreme slowness, even before the blow-pipe flame. It differs from charcoal formed at a high temperature, in not conducting electricity more than the diamond." I regard this experiment as of a capital nature, and an application of M. Daubrée's theory to explain the origin of anthracite coals of this country. I was surprised to see how completely it will explain all the phenomena, and how perfectly it clears up the difficulties we have encountered in our endeavors to explain the origin of anthracite, or non-bituminous coals. It was formerly supposed that anthracite was a more ancient deposit than ordinary bituminous coals, but the identity of the fossil plants of the bituminous and the anthracite coal fields, soon overthrew that theory. Then the hypothesis still commonly accepted was, that the coal was originally bituminous, and lost its bitumen, by the agency of heat, during the epoch of disruption, in which the anthracite coal measures were tilted up, and that by pressure the formation of spongy coke was prevented, and the coke was compressed into the form that anthracite now presents.

This theory, so full of difficulties, and so incredible, may now be dispensed with, and the 'experimentum crucis' of M. Daubrée may be applied to show, that the same kind of vegetable matter which under some circumstances formed bituminous coal, under others might produce anthracite. All we need is the application of water heated under pressure to 400° centigrade, and perhaps giving a longer time, as Nature could well afford, to the experiment, the result could have been produced at even a lower temperature. All the conditions required for this grand experiment, we can readily imagine.

First, an accumulation of vegetable matters, such as coal is known to be made of.

Second, submergence.

Thirdly, igneous agency, which effected the conversion of the vegetable matter into anthracite, and furnished the power whereby the whole formation was again raised above the waters.

Every one, familiar with the anthracite fields of Pennsylvania, knows that tremendous forces have exerted themselves in raising those great coal measures, and that the margins of the coal troughs are turned up at a bold angle, and the strata are broken and powerfully disrupted—phenomena indicating great disturbance, which undoubtedly was accompanied by an elevation of temperature, fully adequate to effect the change of vegetable matters into perfect anthracite. Where such forces, and such a high temperature did not manifest themselves, as in the coal basins of western Pennsylvania, Ohio, and in all the great western regions, where the coal seams exist, the coals are bituminous, and in direct ratio to the smallness of the disturbances they have undergone.

Did space permit, we could extend this theory to the explanation of many details of great practical and scientific interest, but we must forbear for the present.

In conclusion, let me say that by the agency of water, highly heated under great pressure, nearly every fact of metamorphism of sedimentary rocks may be explained. A humid mass of materials thus permeated by heat, would undoubtedly undergo various chemical changes and re-combinations, and crystals, which we cannot form by dry heat, would be readily produced.

If to this we add the chemical influence of sea-water and of mineral springs, as shown by Forchammer, Marignac, De

Sénarmont and Hunt, as cited in the last Report on the Canadian Geol. Survey, we can readily account for the formation of Dolomites, Serpentines, Soapstones, and many other rocks, the origin of which was before enveloped in obscurity.

Add to this the effects of metaliferous emanations, sublimed chlorides of iron, copper and silver, with the mechanical elevation of the vapors of many other minerals, and perhaps of the solution or vapor of chloride of gold, and we shall be in a position to account for the filling not only of highly inclined veins, but of caverns, and even the interlamination of metals and metaliferous ores in the stratified rocks. So also, galena being entirely volatile, we can easily understand how it came to invade the cavities in the western fossiliferous limestones, and to appear in rocks of nearly all ages below the oolite and chalk series. Chemistry must now become the mentor for the geologists who would venture to solve the interesting questions of metamorphism, and to explain the origin of veins, and the influence of one rock on another. Depositions of metals and ores, and of the metals from vapor, by galvanic electricity, will serve to throw much light on the origin of veins. This is a region as yet but little explored, and one that promises a rich reward in science; while a correct theory cannot fail to throw light on practical operations.

Art. V.—NOTICE OF NEW LOCALITIES, AND INTERESTING VARITIES OF MINERALS, IN THE LAKE SUPERIOR REGION: SUPLEMENTARY TO THE CHAPTER ON THIS SUBJECT, IN PART II. OF THE REPORT OF FOSTER AND WHITNEY.*—By J. D. Whitney.

Since the publication of the second part of our "Report on the Geology of the Lake Superior Land District," in 1851, some materials, illustrative of the mineralogy of this region, have accumulated in my note-books, which, in the present communication, I have put together in the alphabetical order of the minerals noticed, for convenient reference. A few of the facts here stated were communicated to J. D. Dana, for the last edition of his "System of Mineralogy," and are

* From the American Journal of Science and Arts, Second Series, Vol. XXVIII, July, 1859.

here repeated, with some additional remarks on the general mode of occurrence or economical importance of the ores and minerals mentioned.

Analcime.—This mineral is quite abundant on Keweenaw Point, and has also been noticed by me on Michipicoten Island; it does not appear to have been observed in the Ontonagon region. The finest locality, however, by far, is at the Copper Falls and Northwestern mines; and, especially, at the last-named place, where work is, for the present, suspended. Both these mines are, in fact, on the same vein, the Copper Falls mine being to the north, and the North-western to the south of the great belt of crystalline, unproductive trap, which runs through the middle of Keweenaw Point. In this vein, analcime occurs in large and almost transparent crystals forming geodes in the greenish magnesian silicate which is the principal gangue of the vein. These crystals are all trapezohedrons, and sometimes occur an inch in diameter; they occasionally have a thin incrustation of chrysocolla. The analcime, at this locality, is almost always associated with the peculiar form of orthoclase, so common in the copper region, and which will be noticed farther on.

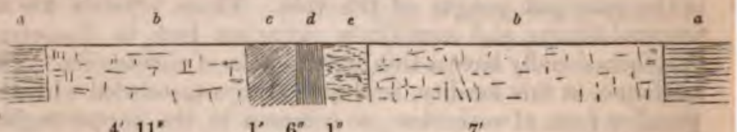
At the Old Copper Falls vein, analcime has been found in radiated-fibrous as well as granular-massive forms, and of a bright red color.

Apophyllite.—The foliated variety, or ichthyophthalmite, was found in great abundance in 1853 in the rubbish thrown out at the workings on the Prince vein, on the north shore. A variety in small, brilliant, deep-red crystalline scales or spangles, disseminated through calcite, forms curious and elegant specimens. The most usual occurrence of apophyllite at this locality is in large contorted plates, somewhat resembling the variety of calcite known as argentine. Crystalline specimens are occasionally met with at the Cliff mine, but none have been noticed in the Ontonagon district.

Barytes.—There are numerous veins of sulphate of baryta on the north shore of the Lake, and especially along that portion lying to the northwest of Isle Royale, as also on that island, and the smaller ones which lie near the main land to the westward of Thunder Bay. These veins vary in width from a few inches to several feet, and are usually made up of quite compact barytes without crystallization, and destitute of accompanying metalliferous ores.

The famous "Prince vein," on Spar Island is one of the most conspicuous and interesting objects, at least in the eye of the mineralogist, in this region. As it makes its appearance on the south side of the island, on the precipitous face of the trap cliffs, which rise nearly vertically from the water, it may be seen from a distance of several miles out on the lake; and when shone upon by the sun, resembles a magnificent waterfall, its brilliant white contrasting strongly with the dark color of the trappean rocks in which it is enclosed.

The course of this vein is about N. 32° W., or nearly at right angles to the general trend of the coast of this portion of the lake. At the southern edge of Spar Island it is fourteen feet and seven inches wide. Here the vein is made up of bands of calcite, crystalline quartz and barytes, as represented by the annexed cross-section.



a, *a*, trap; *b*, *b*, coarsely crystallized calcite; *c*, barytes; *d*, calcite with copper pyrites; *e*, quartz and calcite.

At the point where this section was taken the ore is confined to a band of calcite in the centre of the vein and about six inches in width. The metalliferous portion of the lode consists here of chalcopyrite and erubescite—in small quantity, however, as compared with the amount of barren veinstone connected with these ores.

On the main land, about two miles distant, the vein reappears a little way back from the shore, where it is much split up; but when followed a few rods farther to the northwest it concentrates again, and appears to have a width somewhat greater than on Spar Island. A drift has been carried in on the vein for a distance of 165 feet, from which most magnificent crystallizations of amethystine quartz and calcite were obtained. An examination of the back of the drift shows that if workings should be resumed here, a rich harvest, for the mineralogist at least, would be gathered, the veinstone being highly crystalline in its texture. The metalliferous contents, however, seem to be chiefly limited to blende. At the point in the level where a winze has been sunk to the

depth of 90 feet, and near the collar of the winze, a considerable quantity of native silver was obtained in fine laminæ between the joints of the blende. A large sum of money was expended here, after the discovery of the rich bunch of silver, but it does not appear that a second one was ever struck. A single minute point of native silver rewarded our patient search of hours among the veinstone for proof of the existence of the precious metal.

In no other vein in this neighborhood were any interesting crystalline minerals observed, although the exposures on the lake shore are usually good.

Chalybite.—This mineral has been observed by Dr. G. H. Blaker in the talcose slates near Marquette; it forms narrow strings and bunches in the veins of milky quartz which ramify through the slates. The quantity is not sufficient to make it of any economical importance.

The same mineral occurs, associated with chalcopyrite, in the quartz veins at Echo Lake, near Saut St. Marie. The geological position of these veins is the same as that of the Marquette slates.

Chrysocolla.—Handsome specimens are found in the Copper Falls vein, forming delicate stalactitic incrustations on the veinstone, and sometimes coating the crystals of analcime.

Chalcopyrite.—Veins of quartz containing this ore are numerous in the trappean rocks of the Azoic series, in the neighborhood of Echo Lake, about 15 miles east of Saut St. Marie. Copper pyrites is the predominating ore at the Bruce and Wellington mines on Lake Huron: it has also been found in veins in the Huron Mts., on the south shore of Lake Superior, where no mining has yet been carried on.

Copper.—The native metal is now the exclusive object of mining enterprise on Lake Superior, no veins producing *ores* being now worked, on either the north or the south shore. The sulphurets, however, are still mined on Lake Huron, in the Azoic rocks, a formation which has not been proved as yet on either shore of Lake Superior, to contain any workable vein of the native metal.

The largest mass of copper yet discovered on Lake Superior was in the 10-fathom level of the Minnesota mine, on the so-called "conglomerate lode," or the copper-bearing vein which lies between the trap and a thin bed of conglomerate that runs through the mining ground, and which has been

opened to a depth of between 80 and 90 fathoms without ceasing to produce largely. This mass was 46 feet long, and is said by the superintendent of the mine to have weighed about 400 tons: a single cut across it exhibited a thickness of six feet of pure metallic copper. This mass was estimated to contain at least 90 per cent. of the pure metal. The operation of cutting it up lasted thirty months.*

Almost all the specimens collected on Lake Superior as *crystallized copper*, are, in reality, not actual crystals, but only imitative forms produced by juxtaposition with the crystalline faces of some mineral substance, and usually of calcareous spar. The large masses which are seen in collections, and labelled "crystallized copper from the Cliff mine," usually exhibit only a few indistinct planes which can be referred to the crystalline force of metal itself.

The finest groups of crystals ever obtained in the copper region were from the Old Copper Falls mine, a locality which has long ceased to be worked; and no other has furnished any specimens to compare with those found here.

The predominating form in these groups was the rhombic dodecahedron; but the octahedron was not of unfrequent occurrence. The diameter of the perfectly formed crystals rarely exceeded one-fourth of an inch, although single crystals from this locality, octahedrons, have been seen as large as an inch across their bases. The finest single crystals, as far as ascertained, are from the Cliff mine, and are tetrahexahedrons. One in my collection, considered by many the most beautiful crystal ever found in the Lake Superior region, is about three-fourths of an inch in diameter, and nearly perfect.

The occurrence of native copper as a pseudomorph after aragonite, reported by Söchling† as from Lake Superior, may with the strongest probability be set town as an error. It is very likely that the pseudomorph in question was from Corocoro, South America, where interesting ones of this kind do occur. There is a very great tendency to confusion in the localities of American minerals sent to Europe, as every mineralogist on this side of the water has learned by experience. No aragonite has ever been found in the copper region, as far

* The size of the pieces into which the great masses are cut for convenient handling under ground and shipment is now much greater than it was formerly: blocks of copper weighing from 8000 to 9000 pounds are not unfrequently brought to the surface and sent off to the smelting works.

† Pogg. Ann. civ. 332.

as I know. Native copper, as a pseudomorph of calcite, has been noticed by me in a single instance, in a specimen from the Old Copper Falls vein.

The specific gravity of the native copper, sawn from the interior of a large mass of the chemically pure metal, has been previously stated in our Report at 8·838; this is lower than that given by Erdmann and Scheerer* as the specific gravity of crystallized copper. The specific gravity of the copper smelted at the furnace near Detroit was found to be considerably less than that of the native metal. A piece sawn from the centre of an ingot, and showing no signs of any air-bubbles, gave a specific gravity of 8·601; another portion of the same ingot taken from near the surface gave 8·570; both pieces appeared, under the magnifying glass, equally free from bubbles.

The copper, which was smelted from masses brought from the Toltec mine, was found on examination to be chemically pure, with this exception, that it contained $\frac{3}{10000}$ of silver, about seven ounces to the 2000 lbs.

Datholite.—Fine crystals of this mineral have been found only at the locality on Isle Royale, which has long since ceased to be worked, the island being now entirely deserted by all except a few fishermen. There are several localities on Keweenaw Point, however, where it occurs in great abundance, but not, so far as I have observed, in handsome crystallizations. The gangue of the Hill vein, on the Copper Falls location, consisted, in a portion of its more northern extension, of a greenish magnesian silicate, penetrated in every direction, and sometimes forming a sort of breccia, with branches and strings of datholite. It is usually massive, translucent, highly vitreous in lustre, and of a light flesh-red color, owing to the presence of a minute quantity of suboxyd of copper diffused through it.

The veinstone of the Ontonagon region had seemed to be quite destitute of this mineral, and it was not until last summer that it was discovered by me in that district. At the Minnesota mine, among the vein-stuff thrown out, some singular nodules were observed looking like rusty cannon balls. On breaking one of these open and examining it, it was found to be datholite, in a singular and hitherto unobserved form.

* Erdmann and Marchand's Journal, xxvii, 194.

The mineral is quite compact, breaking with a conchoidal fracture, perfectly white, opaque, and resembling in its physical character the purest and most close-grained marble. Its hardness = 4·5 ; specific gravity 2·983.

An analysis of this mineral by Prof. C. F. Chandler, gave the following results :

Silica, ...	37·41
Oxyd of iron and alumina, . . .	·35
Lime, ...	35·11
Boracic acid (by loss), . . .	21·40
Water, ...	5·73
	100·00

The quantity of datholite which is found on Lake Superior is very considerable, but it does not occur as a constant ingredient of the veinstone in any of the large mines now worked ; and it is not probable that it will become of economical value for the extraction of the boracic acid it contains, however interesting it may be in a theoretical point of view, as connected with the origin of the cupriferous veins.

Hematite.—The purity of the mountain masses of iron ore, which are now extensively mined at various points from 14 to 17 miles west of Marquette, may be inferred from the following analyses recently made of specimens from the three principal mines, or quarries, as they may more properly be called. The specimens are, indeed, selected ones ; but an inexhaustible supply of ore of the same quality could be obtained, without rejecting any considerable amount of the stuff which is quarried out, were it desirable to ship a perfectly pure ore. The average yield of the ore shipped would, in point of fact, fall but little below that given by the following analyses.

	I.			II.		III.	
	a.	*b.*	*c.*	*a.*	*b.*	*a.*	*b.*
Insoluble,	1·02	·80	·54	7·92	7·96	1·99	2·05
Iron,	69·41	70·22	69·96	64·42	64·01	68·81	
Oxygen and traces of lime, &c.,	29·57	28·98	29·50	27·66	28·03	29·20	

I. is ore from the Jackson, II. from the Cleveland, and III. from the Burt or Lake Superior mountain. The fragments analyzed were, in each case, broken from the different

portions of the same large specimen, one object being to ascertain what the variations in the quantity of oxygen were, in different portions of the same mass. I. *c.* is the mean of three closely-agreeing determinations.

In the above analyses, the iron having been precipitated from the chlorohydric acid solution by ammonia, the filtrate was evaporated to dryness and ignited, and in no case did the residuum amount to more than a few hundredths of one per cent. In I. *c.* and III. *b.* there was a weighable quantity of lime present, amounting, in each case, to 0·05 per cent. It was not possible, in any instance, to obtain a weighable amount of alumina. The oxygen was therefore determined by the loss, as giving more accurate results than could be obtained by the process of reduction with hydrogen. It appears, therefore, that these ores are mixtures of the peroxyd with a minute and varying portion of the magnetic oxyd.

Both the Burt and Cleveland mountain ores show minute crystals of magnetite scattered through their mass; in the Burt ore these crystals are from $\frac{1}{20}$ to $\frac{1}{25}$ of an inch in diameter; in the Cleveland, so small as to be hardly visible without a magnifying glass. No sulphur or arsenic could be detected in any of the specimens examined. The insoluble portion consists of silica, with only traces of lime, alumina and magnesia: this silica is partly in combination with the iron in the form of a silicate of iron, and partly present in the form of grains of quartz. On the whole, it may be said with truth that these ores surpass in purity any known to exist elsewhere in the world in any thing like the same quantity.

Leonhardite.—This mineral has been observed only in the Old Copper Falls vein, where it was very abundant; but a careful investigation would probably reveal its presence at other localities. An examination was made of this mineral to ascertain at what temperature it parts with a part or all of its water, with reference to H. Rose's investigations on Laumontite, which he has shown to lose a portion of this constituent at 100° C. The results gave on the mineral in small fragments:

Dried at	*Loss of weight.*
80°	1·46 per cent.
90°	0 "
100°	0 "
Ignition,	11·89 "

The 1·46 per cent. is probably not essential to the constitution of the mineral; the loss by ignition agrees well with the formula which takes the oxygen ratio of the bases and silica as 4 : 9, and 12 H.

Limonite.—This ore of iron has recently been discovered, and for the first time on Lake Superior in any noticeable quantity. It occurs at the Jackson iron mountain, where it forms beds of several feet in thickness, occupying depressions in the anhydrous ore, from the decomposition of which it may have been formed. The analysis gave the following results:

Silica,	6·54
Iron,	60·03
Water,	9·31
Oxygen and traces of lime and magnesia,	24·12
	100·00

No sulphur or manganese could be detected; the original ore appears to have been only partially converted into limonite, as the quantity of water given by the analysis is considerably less than that required to form a hydrous peroxyd of iron. It is used at the Pioneer Furnace, near the Jackson Mountain, and considered to aid in the reduction of the ore.

Manganite.—Handsome specimens of this mineral were given me by Dr. G. H. Blaker, of Marquette, as having been procured in that vicinity; the exact locality is not known to me.

Nickel and Copper, arseniuret of.—This is the same mineral noticed by T. S. Hunt (this Journal, [2], xix. 417), and afterwards more fully described in the Report of the Canada Geological Survey, 1853-6, p. 388. The results of my analyses, made two years ago, confirm entirely those already published by Mr. Hunt; the mineral, which appears homogeneous in composition, being in fact a mixture of the arseniurets of copper and nickel.

Two analyses of different specimens broken from the same mass gave as follows:

	I.	II.
Arsenic (by loss),		47·01
Copper,	14·56	20·94
Nickel,	33·35	31·24
Silver,		·24
Gangue,		·57
		100·00

Specific gravity 7·527.

In II. the quantity of arsenic required to form with the copper domeykite, and with the nickel copper-nickel, is 47·86 per cent., which agrees pretty nearly with that given by the analysis.

The specimens obtained by me on Michipicoten island in 1853, are in coarsely crystallized calcite, and form nodules having a structure in concentric layers. The portions selected for analysis appeared perfectly homogeneous and had almost exactly the color and general appearance of copper-nickel. This ore was obtained in mining for silver on the island, from the trappean rocks ; but on examining the excavations it did not appear that there was any regular vein of this or any other metalliferous mineral, the ore occurring in irregular nodules disseminated through the trap. There is little reason to believe that either nickel or silver occur at this interesting locality in sufficient quantity ever to become the object of a profitable mining enterprise. The beds of rock appear to be too thin, and their changes of lithological character too sudden, to admit of the development of well characterized veins.

Orthoclase.—In almost every collection of Lake Superior specimens may be seen bunches and geodes of minute reddish crystals, accompanied by native copper, calcite and the zeolites, the usual vein-minerals of that region ; these crystals are usually labelled "stilbite," but they are, in reality, orthoclase, as is evident from their physical characters and chemical composition.

The mineral here referred to, which has, on casual inspection, but little resemblance to feldspar, is the same one noticed on page 102 of our Report, where an imperfect analysis of it is given. The peculiar interest attaching to this anomalous occurrence of the substance in question seemed a sufficient reason for completing its analysis, and adding some further remarks on its associations.

This mineral occurs in minute crystals which are rarely as much as one-tenth of an inch in length ; they are rhombic prisms, but not very distinct, nor brilliant enough to be measured by the reflecting goniometer. The angle of the prism is about 118°, or near that of I on I, in common feldspar. The terminations of these prisms are usually rough and indistinct, but formed by a single plane, probably $1i$; more frequently the crystals are aggregated together into a confused crystalline

mass, the individuals being too minute and ill-defined to be made out without a magnifying glass. The mineral agrees in its physical character with orthoclase, fusing before the blowpipe with some difficulty to a blebby glass.

The analysis gave :

Silica, ...	65·45
Alumina, ...	18·26
Oxyd of iron, ...	·57
Oxyd of manganese, ...	*trace*
Potash, ...	15 21
Soda, ...	·65
	1·0·14

The above results indicate, beyond the possibility of a doubt, that the mineral is really orthoclase.

The occurrence of feldspar as an associate of, and in intimate connection with, the zeolitic minerals, which form so large a portion of the gangue of the cupriferous veins, and, indeed, its presence at all in a vein-stone, is a matter of too much importance not to be dwelt upon. Instances of this kind are, as yet, sufficiently rare, and there are some points connected with the occurrence of the feldspathic element in the Lake Superior veins which add to the interest with which these specimens are invested.

Orthoclase has been recognized and described as occurring in the mineral veins of Schemnitz and Kongsberg,* although the possibility of such an association has, until within a few years, been hardly allowed. The well-established fact of the existence of feldspar as a pseudomorph, of the form of laumontite and of analcime, in the trap of the Kilpatrick hills, near Dumbarton, Scotland, furnishes incontestable evidence of the possibilityof the formation of this mineral in the moist way, and the phenomena exhibited on Lake Superior in connection with the association of feldspathic and zeolitic minerals, point as clearly to this conclusion as they do to the necessity of rejecting the igneous theory of the origin of the veins themselves.

The variety of orthoclase of which the analysis has been given above is found in almost all the mines, from the extremity of Keweenaw Point to the Ontonagon; but in the latter district it is most abundant. At the Northwestern

* See Leonhard and Bronn's Jahrbuch, 1850, p. 43; also Bischof's Geology, ii. 330.

mine, the association of orthoclase and analcime is almost constant, and there are few geodes which do not exhibit delicate crystallizations of the first-named mineral so situated with reference to the other as to lead to the conclusion that their formation must have been going on at the same time and under the same circumstances. The crystals of orthoclase are also, at this locality, frequently scattered, singly, over delicate incrustations of a very soft magnesian mineral, which hardens somewhat on exposure to the air, and which is probably saponite, but of which I have never been able to procure enough for an analysis. This mineral seems to have been the last formed of all the vein-minerals of this region.

At the Old Copper Falls vein, orthoclase of a bright red color occurs, lining the interior of cavities in the gangue, and forming, with associated calcite and crystallized copper, specimens of great beauty. The calcite, not unfrequently, has crystallized over the orthoclase in such a manner as to be colored deep-red by it. The same may be said in reference to the joint occurrence of natrolite and orthoclase at this locality. There is clear evidence here of the contemporaneous formation of the copper, natrolite, calcite and orthoclase.

In the Ontonagon region, the minerals associated with orthoclase are chiefly quartz, epidote, and calcite. At the Aztec and Ridge mines, geodes lined with delicate crystallizations of these are not unfrequent. Minute crystals of solecite or natrolite have been noticed in the same connection. At the Minnesota mine, the large crystals of quartz, formerly obtained there in abundance, were frequently encrusted with a thin layer of crystals of orthoclase.

It may be remarked, that the crystals of this mineral are, throughout the whole copper region, remarkably uniform in their size, color, and general habit. They are rarely more than a few hundredths of an inch in length, have the same crystalline form, and are, with rare exceptions, of a light reddish color.

Feldspar, in no instance, so far as has yet been observed, forms the bulk of the veinstone ; it is only met with in comparatively minute quantity, although occurring in numerous localities. Only a single instance has been noticed where a crystal had a length as great as one tenth of an inch, and this was an imperfectly formed one.

Note.—Weissigite, described by Jenzsch, is undoubtedly orthoclase, as suggested in Dana's Mineralogy, p. 513 ; this

was found in a phorphyritic amygdaloid, with chalcedony and quartz, and is spoken of by Jenzsch as the first known instance of the occurrence of a feldspathic mineral in an amygdaloidal cavity of a rock of this class.

Serpentine.—Well-characterized serpentine has not yet been found in the Lake Superior region; but a substance closely related to this mineral, and, in fact, differing from it chiefly by the substitution of protoxyd of iron, in a large but varying amount, for a portion of the magnesia, forms the headland of Presqu' Isle, near Marquette. An imperfect analysis of this rock was given in Foster and Whitney's Report, Part II. page 92. Since the publication of that analysis, new specimens have been collected, and a more thorough examination made of it, of which the results here follow.

The substance is of a deep green color, so deep as to appear almost black; its powder is light greenish-gray. Its hardness is a little above that of common serpentine. It is readily attracted by the magnet, when broken into small fragments. In some specimens minute octahedral crystals of magnetic iron ore, disseminated through the mass, can be seen with the aid of the magnifying-glass. The substance is readily attacked by chloro-hydric acid, even in the cold, if finely pulverized; but a small portion of unattacked mineral remains behind when the insoluble residuum is treated with carbonate of soda in the usual way. It amounts to from two to six per cent., and appears to be an insoluble silicate mechanically mixed with the serpentine; it is probably hornblende, but has not been analyzed.

The analyses of three specimens collected at some distance from each other, gave the following results, as the composition of the soluble portion of the substance:

	I.	II.	III.
Silica,	36·95	37·25	
Magnesia,	33·07	28·67	14·83
Soda,	·97	1·16	
Protoxyd of iron,	16·50*	14·14	19·52
Peroxyd of iron,		6·75	12·90
Water,	10·40	10·89	
		98·86	

In analysis II. in which all the ingredients are determined, as well as the relative amount of the oxyds of iron, the calcu-

* Estimated as protoxyd.

lation gives, for the ratio of the oxygen of water, protoxyd bases and the silica, leaving out of consideration the peroxyd of iron as being a mechanical intermixture, the numbers $1:1{\cdot}49:1{\cdot}99$; or, almost exactly, $1:1\frac{1}{2}:2$, which is the ratio given by the analyses of serpentine.

Silver.—Native silver still continues to be found in considerable quantity, in connection with the copper, at the principal mines on Lake Superior, especially at the Minnesota and the Cliff. The amount obtained at the Minnesota in 1857, by the Company, was $655,44: this, however, was but a small portion of what was really found, as the miners are well known to appropriate almost all the silver they discover. The metal has never been noticed by me in distinct crystals, except in one instance, namely, at the Copper Falls mine, where a few well-formed cubes about one-tenth of an inch in diameter were obtained.

Most of the fine specimens of silver from the Lake have been associated with calcite, which is dissolved away by an acid, leaving the metallic mass exhibiting the impressions of the planes of this mineral, as is the case with the copper specimens, as before remarked.

Zeolites.—To close this article, a few remarks may be added on the occurrence of the zeolitic minerals in the Lake Superior region, and especially as vein-stones.

By far the most abundant zeolites of the copper-bearing veins are prehnite and laumontite, or the closely allied species, leonhardite. The cases are rare, however, in which either of these minerals constitutes the bulk of the gangue of a vein, except in the case of narrow strings and bunches of limited extent. Quartz and calcite are the predominating vein-minerals, the zeolites being decidedly subordinate to these, especially in the great productive lodes. The zeolites, moreover, are chiefly confined to transverse veins, or those crossing the formations at a high angle: in the Ontonagon region, where the great lodes have the same strike as the beds of rock, zeolitic minerals are of comparatively rare occurrence in the veinstone. In this class of veins, quartz and silicious material greatly predominates over all the other minerals, and there is much more rock intermixed with the vein-stone proper. Datholite may be noticed in a few instances among the transverse veins, as forming the larger portion of the gangue near the surface; but in no such case has mining been carried to any

considerable depth, so as to ascertain how far this state of things continued.

On the whole, the diminution of the zeolitic portion of the vein-stone is marked as the mines are extended downwards: the only crystalline mineral observed in a recent careful examination of the Minnesota mine, at a depth of from 70 to 80 fathoms, was calcite. Traces of what appeared to be laumontite were noticed along the selvages of the lode, which at this depth is quite as rich in copper as anywhere above; but the lode seemed to be very compact in its texture, and no other zeolite was seen in it.

The entire, or almost entire, absence of some of the more common zeolites from the Lake Superior region is worthy of notice. Those minerals which are most characteristic of the Nova Scotia trappean rocks are almost entirely wanting on the Lake. Neither chabazite, stilbite or heulandite have ever been observed by me in the copper region, on the south shore of the Lake.* The analogy of lithological character between the traps of Nova Scotia and those of Lake Superior, which has frequently been urged as a reason for considering them of the same geological age, and which has not yet been made evident by an analysis of the rocks themselves, fails entirely when considered with reference to the associated minerals.

Of the zeolites occurring on Lake Superior, pectolite, leonhardite and chlorastrolite appear, thus far, to be limited to a single circumscribed locality, while harmotome is reported in only a doubtful crystal. The only new zeolitic mineral noticed is chlorastrolite, which is quite common along the beach of Isle Royale, for a distance of two or three miles, but which has not been discovered at any other point on the Lake.

The occurrence of the zeolites on Lake Superior is not absolutely, although chiefly, confined to veins. All the fine specimens of crystallized minerals of this class have been obtained from the cupriferous veins, so that this may be considered as the normal mode of occurrence in this region. Where the trappean rocks assume an amygdaloidal structure, we have, occasionally, prehnite, chlorastrolite, etc., in radiating fibrous masses, filling the cavities; but quartz in the form of agate and chalcedony and calcite are much more common. There are

* These minerals are reported by Messrs. Owen and Norwood as occurring on the Minnesota shore of the Lake, west of Pigeon River, a region to which my explorations have not extended. I have, however, examined numerous specimens from that part of the Lake, without having discovered either of those zeolites.

occasional flat tabular masses of laumontite mixed with prehnite found lying in the direction of the lines of bedding of the trap, but these are thin and of limited extent. Many of the trap amygdules are filled with a mineral resembling chlorophæite, and others with saponite. Most of the substances thus occurring are only to be recognized by chemical analysis, as they are generally finely fibrous or massive.

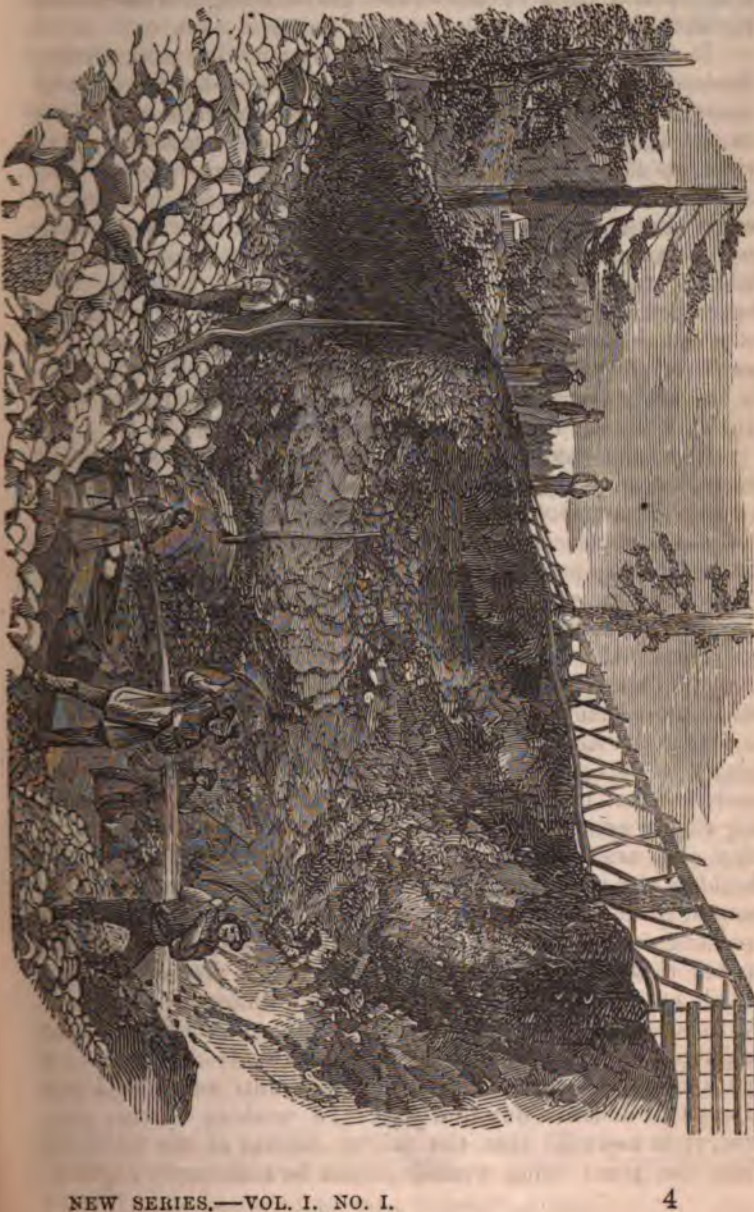
Art. VI.—The Hydraulic Process of Mining.*—By William P. Blake.

In California, as in other gold regions, the attention of the miners was first given to the deposits along the streams, for in such places the gold was not only more uniformly and certainly present, but water was at hand with which to separate it from the gravel and clay. As the number of miners increased and the deposits became crowded or worked out, the hills and dry hollows were prospected, and pay-gravel from the richest placers was carted or wheeled in barrows to some neighboring stream, and there washed. It soon became evident that the elevated placers or "dry diggings" were so extensive that water could be conveyed to them by canals and ditches, much more profitably than to attempt to carry the earth to the water. The first ditches were upon a small scale, but were found to be so profitable and to produce such great results, that more extensive and expensive canals were immediately projected. Rivers were ascended for miles, near to their sources in the Sierra, where their waters had not lost the icy coolness of the snow fields from which they came, and were turned aside into canals, which wound with a uniform grade around the irregular slopes of the hill-sides, until the water was delivered at the placers on the tops of the hills. The great power thus saved by keeping the water at such an elevation above the surrounding streams was soon realized; the old machines were thrown aside, and even the sluice in its turn gave way wherever practicable to the *Hydraulic process*, which for rapidity and efficiency has not been surpassed. In this process, the force of a jet of water under great pressure

* From a Report on the Gold Placers of the vicinity of Dahlonega, Georgia. Boston, 1859.

is made available for excavating and washing the auriferous earth. The water issuing in a continuous stream, with great force, from a large hose-pipe, like that of a fire-engine, is directed against the base of a bank of earth and gravel, and tears it away. The bank is rapidly undermined, the gravel is loosened and violently rolled together, and cleansed from any adhering particle of gold, while the fine sand and clay are carried off in the water. In this manner, hundreds of tons of earth and gravel may be removed, and all the gold it contains liberated and secured with greater ease and expedition than ten tons could be excavated and washed in the old way. By this method, all the earth and gravel of a deposit is moved, washed, and carried off through long sluices by the water, leaving the gold behind. Square acres of earth on the hill-sides may thus be swept away into the hollows, without the aid of a pick or shovel in excavating. The earth is not handled; in fact, water performs the labor, and moves and washes the earth at one operation, while in excavating by hand the processes are necessarily entirely distinct. The value of the process, and the yield of gold by it as compared with the old methods, can hardly be estimated. The water acts constantly with uniform effect, and can be brought to bear upon almost any point, where it would be difficult for men to work. It works on at the base of toppling banks of boulders and clay, regardless of the crash which must soon come as the foundations are ripped out and washed away by the fury of its onslaught. Great indurated masses of dirt which are thus made to fall upon the washed bed-rock below are soon broken up; the earth and gravel are carried off down the sluice, and only the largest masses of rock are left behind. The process is especially effective in a region covered with trees, where the tangled roots would greatly retard the labor of workmen. In such places, the stream of water washes out the earth from below, and stump after stump falls before the current, any gold which may have adhered to the roots being washed away. The pressure is obtained simply by the weight of the water, it being conveyed from a ditch or reservoir above, in stout hempen hose or plank boxes, fitting tightly end to end. A head or pressure of from sixty to one hundred feet is employed, according to circumstances.

The annexed engraving is from a daguerreotype of the mining claim of Messrs. Blake, Tyler and Webster of Michigan City, California, and shows the operation of the hydraulic



hose upon a bank of auriferous gravel charged with quartz boulders.

In California the whole art of placer-mining was revolutionized by this hydraulic process, and the production of gold received a fresh and lasting impulse. Square miles of surface on the hills, rich in gold, which have lain untouched, now yield up their treasure to the hydraulic miner. In that region, where labor can scarcely be obtained, and is so costly, water becomes the great substitute for it, and, as we have seen, is more effective and economical in its action than the labor of men. Every inch of water which can be brought to bear upon a placer is valued as the representative, or producer, of a certain amount of gold. Wherever it falls upon the auriferous earth it liberates the precious metal, and if the gold is uniformly distributed through the earth, the amount produced is directly as the quantity of water used.

As a labor-saving process, the results of this method compare favorably with those obtained by machinery in the various departments of human industry, where manual labor has been superseded. With one pipe of an inch and a half or two inches aperture, and a pressure or head of ninety feet, a boy can excavate and wash as much auriferous earth in one day as ten or fifteen men could without its aid. It is common to estimate the work of a pipe as equal to the labor of ten men; in some locations a pipe of the size mentioned might effect more than twenty men in the same time. The water is ever active and untiring, and works as rapidly in inaccessible places as upon an exposed bank. The quantity of earth moved will of course vary greatly at different places, depending chiefly upon its character; whether sandy, a mixture of clay and sand, or clay alone. The amount of gravel and boulders also varies greatly in all gold placers. From measurements made last year in North Carolina, where a pipe of medium size had been in use at the Wilkerson placer, I estimated that with a head of sixty feet and a pipe of one and a half or two inches in diameter, over a thousand bushels of earth could be moved and washed in a day. If this estimate is correct, earth which contains only the twenty-fifth part of a grain of gold in a bushel, or about two mills' worth, will pay about two dollars a day to a pipe. In washing by this process, it is essential that the fall or descent of the bed-rock from the point being washed should be sufficiently rapid to

insure a swift current in the waste water, so that it will carry the loosened sand and clay away in suspension or force it along the sluice-boxes.

It is to the ingenuity and enterprise of the miners of California that this great advance in the art of placer-mining is due. The great bulk of the gold now obtained is produced by hose-washing and sluicing; showing conclusively the great extent and importance of the dry or hill-placers. To show, also, the extent to which the operations on this class of placers have been carried in California, and the importance of water at an elevation in gold mining districts, the following general statements and tables, compiled from official sources, are presented.

It is stated* that at the close of the year 1858 there were 5726 miles of artificial water-courses for mining purposes in the State of California, constructed at a cost $13,575,400. This estimate is exclusive of several hundred miles of new ditches in course of construction, and of the many subordinate branches of the ditches, the aggregate length of which is estimated at over one thousand miles. Most of the ditches have been constructed by individuals, or small companies of from three to ten persons, but the works compare in their magnitude and cost with the most important public works.

TABLE OF DITCHES FOR MINING PURPOSES IN CALIFORNIA, IN 1858.

County.	*No. of Ditches.*	*Aggregate length, Miles.*	*Capacity in Inches.*	*Cost of Construction.*	*Assessed Value.*
Amador,	36	531	......	880,400	280,600
Butte,	......	400	......	......	......
Calaveras,	54	550	12,019	1,600,000	991,000
El Dorado,	43	1,150	......	1,600,000	617,970
Klamath,	......	64	......	104,000	......
Mariposa,	10	65	......	135,000	......
Nevada,	86	696	......	1,700,000	953,700
Placer,	35	550	......	1,550,000	283,160
Plumas,	92	201	16,775	600,000	210,000
Sacramento,	8	163	......	800,000	......
San Joaquin,	2	21	......	108,000	......
Shasta,	24	104	9,000	300,000	......
Sierra,	70	183	......	......	420,650
Siskiyou,	16	......	......	......	100,000
Stanislaus,	3	13	......	56,000	......
Trinity,	94	163	......	500,000	......
Tuolumne,	14	425	......	1,481,000	......
Yuba,	34	241	......	700,000	......

* See California "State Register" for 1859.

The above table shows the number of ditches in the principal mining counties at the close of the year 1858, with their lengths and cost of construction. It is compiled in part from the Reports of the County Surveyors and Assessors, and in part from the pages of the California Register, where the names of over three hundred and seventy Water Companies are given in one table.

The following are some of the principal ditches by name, but the list might be greatly extended. The authorities from which it is compiled seldom state the *size* of the ditches or their capacity, thus leaving it difficult to determine the works of really the greatest magnitude :

Name.	*County.*	*Source of Water.*	*Length miles.*	*Cost.*
Butte,	Amador co.,	North Fork Mokelumne,	50	$400,000
Table Mt.,	Calaveras,	San Antonio Cr.,	65	60,000
Union Water Co.,	"	Stanislaus R.,	78	320,000
Bear Creek,	Mariposa	Bear Creek,	19	12,000
Middle Yuba,	Nevada,	Middle Yuba,	26	100,000
El Dorado Water Co.	Placer,	El Dorado Canon,	18½	30,000
Deer Creek Water and Mining Co.,	Sacramento,	Deer Creek,	14	100,000
Clear Creek,	Shasta,	Clear Creek,	53	140,000
Tuolumne Hydraulic Co.,	Tuolumne,	Tuolumne River,	60	300,000
Columbia and Stanislaus,	"	Stanislaus,	80	600,000
Auburn and Bear River,	Placer,	Bear River,		75,000

It is stated that most of the California ditches pay from one to three and five per cent. per month on their cost, after deducting all expenses of repair and management.

In a little work entitled *California and its Resources*, by Ernest Seyd, the following are reported as accurate statements of the profits of some of the California water companies :

Columbia Water Company,	4	per cent.	per	month.
Canal and Rich Gulch,	12	"	"	"
Ditch on the head of Rich Gulch,	6	"	"	"
Two Flumes in Butte County,	5	"	"	"
Prairie City Canal Company,	3	"	"	"
Coon Hollow Canal,	10	"	"	"
Two Ditches at Coloma,	5	"	"	"
Rock Creek Ditch, near Georgetown,	5	"	"	"
Natoma Water Works, (Mormon Island,)	12	"	"	"
Auburn and Bear River,	20	"	"	annum.

"All these are works made by capital borrowed at extravagant rates of interest."

"A small ditch at Jackson, which cost $1700, pays $100 a day."

"The South Fork of the American River Canal cost between $600,000 and $700,000, and yields a profit of $2500 a week. The water companies in Nevada county pay from six to thirty per cent. per month." Page 37–38.

Most of these ditches require costly fluming across deep ravines or valleys, and on the course of one of the canals now being constructed, [1858,] the water is to be carried across a valley in a suspended flume, 2800 feet in length, sustained by towers rising 130 feet above the bottom of the valley below. These enterprises are seldom undertaken by those engaged in mining, the tenure of the placers being such that water is sold out to each claim at so much per inch for each day of eight or ten hours. When water was first introduced, the most extravagant prices were paid for a supply of a few inches, in localities where the yield of gold was very great, and in many cases where the supply was limited, the same water was used twice or thrice over, passing from one claim to another, until it became so thick that it would scarcely flow. The price per inch of water in 1851, was about $3,00; so that a claim using twenty inches a day, paid sixty dollars for water. The price gradually decreased to fifty cents, and is less at the present time. When water is sold by the inch it is delivered to the consumers from a horizontal aperture one inch high and twenty-four inches long. This opening is at the side of a box twenty-four inches square and six inches deep, and is opened or shut by a slide. The opening is graduated to half inches, and the slide is pushed in or drawn out until the desired flow of water is obtained. As the box is kept full of water from the ditch, the delivery is under a constant pressure of six inches. As an example of the extravagant prices paid for water when first conducted to the high placers, I extract the following from my report to the U. S. Government:*

"Water was first brought to the Nevada Hills by the Rock Creek Ditch. This was seven miles in length, cost about

* *Report of a Geological Reconnaissance in California, &c.* New York, 1858. Page 268.

$14,000, and yielded from the sale of water, $30,000 in the first two months. Water was sold several times over, or rather, it was used by several parties in succession, until from the quantity of fine slime in suspension, it became thick, so that it would no longer run. For a supply of eight inches, the first parties paid two ounces a day; the second twenty-four dollars; the third, one ounce, and so on, down to four dollars. The aqueduct was afterwards sold for about three times its original cost, and has since paid fair dividends even for California. Water is now sold for fifty cents an inch, [1854.]"

A correspondent of the *Philadelphia Ledger*, in October, 1858, writes as follows: "People said the mines of California could not be worked in the dry season, for want of water. But within the last five years they have made 4405 miles of artificial canals for mining purposes, at a cost of $12,000,000, and at this time another 1000 miles are being constructed. Now, a vast deal of this canalling is over the most wild, rocky, and precipitous country; jumping over awful chasms, and plunging down fearful abysses; trestle work, story piled upon story, and wooden fluming zigzagged at every angle, (rough, as yet, truly, but with strength adequate to its purpose,) may be seen winding for miles and miles its tortuous course, leading mountain streams far away from their native channels, and giving to the driest diggings water superabundant. The waterfall at the end is generally very great, and it is turned to curious account."

The Rev. Dr. Bushnell, in writing upon the characteristics of California, thus describes the Hydraulic process: "In the mining country, the natural beauty of the scenery is defaced by another process. Here a thin but stately growth of evergreens is sprinkled over the generally graceful slopes and roundings of the hills, and a pure crystal stream leaps along down the trough of the hills, over cliffs of rock and pebbly beds. But the miner comes. Finding gold that will 'pay' in the soil, he rents a head of water from the Ditch Company, whose ditch, bringing on the water from some level far up the Sierra, flows it along from hill-top down to hill-top, and across from one hill to another, leaping hollows and ravines on wooden trestle work, sometimes even 200 feet high, till it reaches a point abreast of his placer, and directly above it. Bringing it down the hill in an immense cotton hose, with a nozzle

pipe like that of a fire engine, he plays it into the side of the hill, with a pressure of perhaps 150 feet fall ; tears down the hill, acre by acre, and floats it off, rolling the loose stones with it down his wooden trunk or sluice, in which the gold is arrested, and so continues till he has carried off a large section of the hill-side, even 100 feet deep. His neighbors are doing the same thing, right and left. Pits also are sunk downward, and tunnels bored in level into the sides of the hills, and the earth from so many burrows is piled at their mouths. The trees are cut down for timber and firewood. The stream of the valley runs thick with creamy richness, and the cliffs and pebbly beds are covered fifty feet deep with stones and mud-washings. The result is a most horrid desolation, of which every line of the natural beauty is gone for ever."*

From California the construction of ditches and the application of the hydraulic process extended to Australia, and within two years past was introduced into North Carolina by Dr. M. H. Van Dyke. In Georgia a company was formed last year to wash the placers along the Chestatee River, but owing to unexpected delays in the completion of the ditch, operations have not yet fairly commenced. The first pipe put in full operation in Georgia was by Mr. Hezekiah Kelly, on lot 793, belonging to the Georgia Gold Company.

Several attempts have been made by others to use cotton or canvas hose, but these were not made strong enough to bear the strain of an effective head of water. With a head of less than sixty feet, satisfactory results may not be expected, especially where the auriferous earth is firmly packed, and consists, in great part, of stiff red clay highly charged with oxide of iron. Not only the *head* but the *volume* is important, for the stream not only has much greater effect upon the bank in cutting it away and dislodging heavy boulders, when a heavy mass of water impinges violently upon it, but the mass or quantity of water is required to form a bold stream or current to carry away the tailings. On this subject Mr. Charles Ellet, Jr., in answer to inquiries made by the Hon. T. L. Clingman, through the Smithsonian Institution, makes the following statement, and gives other observations upon the capacity and grade of ditches, which are also appended.†

* New Englander, xvi. i. Feb. 1858, p. 158.

† First published in the *Washington Globe*, February 9th, 1857, together with Mr. Clingman's letter of enquiry.

"The power of water is, generally, the product of the fall, or *effective* head into the volume discharged. But, in this particular application, I cannot admit that principle, and am of opinion that, the head being constant, the effect will depend much on the *mass* of water discharged by a single pipe. In other words, that it will be found better to discharge through the largest manageable orifices—that a greater effect will be produced by the column discharged from one pipe of two inches bore, than by those from four pipes of one inch bore—though the volume and velocity are the same in each case. To obtain good results requires large, concentrated masses of water.

"It makes no difference whether the conducting pipes leading from the canal to the orifices of discharge are perpendicular, or follow the slope of the ground. At least, the difference can be reduced to a very small quantity. What is required is simply very large pipes, to convey the water from the canal to the orifice or discharge."

* * * * * *

"The following calculations meet the cases submitted by Mr. Clingman, assuming his canals to be of rectangular sections:

"Canal three feet by three feet:

Slope	2 ft.	per mile—	mean velocity	1.7	ft.	per second.
"	4	"	"	2.5		"
"	6	"	"	3.2		"
"	8	"	"	3.7		"

"The volumes delivered by this ditch, and with these slopes, will be—with slopes of

2	ft. per mile—	1.7 × 9=15.3	cubic ft.	per second.
4	"	2.5 9 22.5	"	"
6	"	3.2 × 9=28.8	"	"
8	"	3.7 × 9=33.3	"	"

"But if the dimensions of the ditch were six feet by three feet, the results would have been for the velocity:

Slope	2 ft.	per mile—	velocity	2.1	ft.	per second.
"	4	"	"	3.1		"
"	6	"	"	4.0		"
"	8	"	"	4.6		"

"And the volumes delivered by this ditch would be—with slope of

2 ft. per mile—	$2.1 \times 18 = 37.8$	cubic ft.	per second.
4 "	$3.1 \times 18 = 55.8$	"	"
6 "	$4.0 \times 18 = 72.0$	"	"
8 "	$4.6 \times 18 = 82.8$	"	"

"Mr. Clingman should observe particularly these facts, viz.:

"The large ditch, six by three, with a fall of only two feet per mile, will convey thirty-eight cubic feet of water per second.

"The smaller ditch, three by three, with a fall of eight feet per mile, will only convey thirty-three cubic feet per second.

"The large ditch, with the small fall, carries some fifteen per cent. more water than the small ditch with the great fall.

"Again: the total head to be used is supposed to be 100 feet, and the length of canal ten miles.

"The larger ditch, with a fall of two feet per mile, delivers its water at an effective height of

$$100 - 10 \times 2 = 80 \text{ feet.}$$

"The smaller ditch, with a fall of eight feet per mile, delivers its burden at an effective height of

$$100 - 10 \times 8 = 20 \text{ feet.}$$

"If I wished to compare the relative *powers* of the water borne by these two ditches, I should express them by the products of their respective volumes into their effective heads—assuming, of course, that the water in each case would be discharged through orifices of equal size:

"The power of the smaller ditch would be expressed by $33 \times 20 = 660$.

"The power of the larger ditch would be expressed by $38 \times 80 = 3040$.

"The large ditch would therefore do more than four and a half times as much work as the smaller one—though it is only twice as large as the smaller.

"The discharge of a round orifice, one inch in diameter, under

"A head of 30 feet will be 147-1000 of a cubic foot per second.

"A head of 60 feet will be 215-1000 of a cubic foot per second.

"A head of 80 feet will be 240-1000 of a cubic foot per second.

"A head of 100 feet will be 267-1000 of a cubic foot per second.

"A ditch of rectangular section, six feet wide and three feet deep, with a slope of two feet per mile, would deliver, as above, 38 feet of cubic water per second. As each pipe, with a head of 80 feet, would discharge 240-1000 of a cubic foot per second, this ditch would keep in action $38 \times 1000\text{-}240=$ 160 pipes of one inch bore.

"This system of working the gold mines must be very effectual. But a great deal of its success will necessarily depend on the skilfulness of the entire arrangement.

"In my opinion, every care should be observed to convey the largest mass of water attainable, to deliver it at the greatest possible height, and to discharge it against the soil to be washed through the largest manageable pipes.

"There are many practical questions connected with this business which should be considered; but they depend for their solution on the shape of the ground, etc.

"Some allowance must be made in the calculations for the necessary loss of water on the way from the stream to the diggings; but this loss will depend on the character of the soil.

"If the soil is argillaceous, it would be advisable to form basins on the line of the canal, wherever it can be done without adding materially to the cost.

"The water ought not to be drawn directly from the shallow canal into the pipes which convey it to the orifices of discharge. There should be interposed a large iron pipe, or a penstock; or the canal, if the ground permit, should be made very deep at that point, so as to force the water into the pipes under a sufficient head.

"Short bends in the pipes should be avoided. The larger the pipes, and the clearer they are kept from all sorts of obstruction, the more violent will be the discharge, and the better the results.

"It is not improbable that it will be found advisable to place the branch of discharge pipes on a *rest*, and handle them by some simple machinery, so as to permit the nozzle of

each pipe to be put very close to the soil—nearer than a man could safely stand. Under such heads as we are considering, and with such a column as I would use, gravel and large stones will be scattered about with great and dangerous violence. In fact, it is the difficulty of standing near enough to handle the pipes, which will be likely to put a practical limit to the column and the velocity of discharge.

"The canal should be allowed to spread out into basins wherever the shape and character of the soil will permit it. These wide places will serve as reservoirs, and frequently save much water."

Next to the hydraulic process or hose-washing, the most important application of water in placer mining is in *sluicing.* The sluice is a long channel or raceway, cut either in the surface of the bed-rock or made of boards. The former is known as the *ground sluice*, and the latter as the *board-sluice.* The ground-sluice is cut in the softened surface or outcrop of the bed-rocks, which are generally of slate, presenting upturned edges like the leaves of a book. In the softened mica slates this resemblance is very great, and the surface is highly favorable to the retention of particles of gold. It is easily cleaned up, as one or two inches in depth of the surface may usually be scraped off with the shovel. The board-sluice is generally twelve or fifteen inches in width, and from eight to ten inches deep, and is made in convenient lengths, so that one can be added to another, until a length of two or three hundred feet or more is obtained. False bottoms of boards are often used to facilitate the retention of the gold, while the stones and gravel are swept away by the rapid flow of the water. Long bars or *rifflers* are generally preferred to cross cleats or holes. The fall or rate of descent of the bottom of the sluice is varied according to circumstances, being arranged to suit the size of the gold and the nature of the drift. One or two feet in a rod, or one foot in twelve, is a common inclination, and with a good supply of water will cause stones several inches in diameter to roll from one end of the sluice to the other. The earth, stones, and gold as they enter these sluices with the water, are all mingled together, but the current soon effects a separation; the lighter portions are swept on in advance, and the gold remains behind, moving slowly forward on the bottom until it drops down between the cleats or bars. The larger stones and coarse gravel are swept on by the current, and after traversing

the whole length of the sluice are thrown out at the lower end. The operation, as in the hydraulic or hose process, with which the sluice is always combined, is a continuous one, and requires comparatively little labor or attention, except to keep the sluice from clogging. In some localities, where the depth of the auriferous gravel and overlying clay and soil is not great, water may be used to as great advantage in the sluice as under pressure. It has this advantage, that the auriferous earth may be washed as high up as the source of supply. The process is a close imitation of the operations of nature in concentrating gold in the deposits along streams.

MINING AND SCIENTIFIC INTELLIGENCE.

GEOLOGY.

SINCE the publication of the last number of the Mining Magazine, several important Reports on the geology of different portions of the United States have been published. Prominent among them are the Geology of Pennsylvania, with a general survey of the Geology of the United States, Essays on the Coal-formation and its fossils, and a description of the coal-fields of North America and Great Britain; by HENRY DARWIN ROGERS, State Geologist, &c., in two volumes 4to, of 586 and 1046 pages, with numerous maps, plates and wood-cuts;—The Report on the Geological Survey of the State of Iowa, by JAMES HALL, State Geologist, and J. D. WHITNEY, chemist and mineralogist, in two volumes, published by authority of the Legislature of Iowa;—First Report on the Geology of Arkansas, by D. DALE OWEN;—Third Report on the Geological Survey of South Carolina, by OSCAR M. LIEBER, and the Reports of progress of the Geological Survey of Canada, by Sir W. E. LOGAN, F. R. S., Director. All of these contain much that is interesting to those interested in mining in the United States; and it is our intention to notice them, and give extracts from their pages in succeeding numbers.

Geological Explorations in New Mexico.—Prof. J. S. Newberry, formerly Geologist and Botanist of one of the U. S. Pacific Railroad surveys, and Geologist of the Colorado Expedition under Lieut. Ives, is now engaged with Major Macomb in explorations about the sources of Grand and San Juan Rivers, the tributaries of the Colorado of the west. Letters received from him by Mr. Meek, dated at Santa Fé, New Mexico, July 18th, give a brief account of his observations up to that time. from which the following was prepared and published in the September number of the *American Journal of Science:*

"Dr. N. following the Santa Fé road from Independence, Mo., to near Burlingame, Kansas, saw nothing but rocks of the upper Coal Measures, but near Burlingame, on the banks of Dragon creek, he found the first Permian forms [the dip in all this region is N. W.] From Wellington to Cottonwood and Turkey creek the Permian was constantly found in the hill-tops, but the valleys were excavated down to the Carboniferous. The Permian was a light cream-colored Magnesian Limestone. From the Little Arkansas to Walnut creek the surface

rocks were Red, Yellow, and White Marls and Gypsum, so characteristic of the Llano Estacado and the country west of the Rio Grande. There were no fossils. These are the beds seen by Meek and Hayden and described by them as between the lower Cretaceous and the Permian in Kansas, some 35 to 40 miles farther to the northeast, and which rocks they state in their paper may be either Jurassic or Triassic —but they (like Dr. Newberry) discovered no fossils in them.

"On the banks of Walnut creek, a tributary of the Arkansas—a little farther west, Dr. Newberry saw the same red or brown sandstone from which Messrs. Meek and Hayden collected the fossil leaves on Smoky Hill river, some 40 or 50 miles farther to the northeast, and also in Nebraska at the Blackbird Hills. In this sandstone and in a gray clay beneath it, he also has found some of the same 'leaves of dicotyledonous trees—willows, &c., precisely as at Smoky Hill, Blackbird Hills and in New Jersey.' These leaves Dr. Newberry pronounces the same which mark the base of the Cretaceous in New Jersey, Nebraska and Kansas. These are the leaves declared by Prof. Heer and Mr. Marcou to be *Miocene!*

"The Cretaceous beds at this point were not seen by Dr. Newberry overlying the sandstone, but on the Canadian, further southwest, as we might expect from the dip, he found this *same sandstone overlaid by the same Cretaceous seen by Meek and Hayden surmounting it in Nebraska.* In these Cretaceous beds,—a whitish marly limestone and shale (Nos. 2 and 3 of the Nebraska section of Meek and Hayden, the Sandstone being No. 1,)—he found *Inoceramus problematicus*, a well-known Cretaceous species, (so in England and various parts of Europe,) as well as in No. 3 of the Nebraska Section—associated with *Ammonites New Mexicana*, *Gryphæa Pitcheri*, (*G. dilatata* var. *Tucumcarii* of Marcou.) Thus we have the same stone which Mr. Marcou and Prof. Heer would make *Miocene*, *overlaid* by beds containing not only well-known and admitted Cretaceous fossils, but along with these the very *Gryphæa* relied upon by Mr. Marcou for the establishment of the existence of the *Jurassic*. So if Mr. Marcou and Prof. Heer are right, the Miocene proves to be older than the Cretaceous and the Jurassic! and the unfortunate American geologists find to their confusion that the roof of their geological edifice was constructed before the foundation was laid.

"Dr. Newberry states also, 'At Galisteo I found upper and lower Cretaceous rocks beautifully exposed, and in the *lower Cretaceous Sandstone* (Jurassic of Marcou) *dicotyledonous leaves*.' 'The [true] Jurassic may be in New Mexico,' he continues, 'but we have not yet detected it —Marcou's Jurassic is certainly not so.'

"The facts elicited by Dr. N. seem however to sustain the Trias in New Mexico. Writing from Abiquia, (near Santa Fé,) New Mexico, he says: 'Here in the red gypsum-bearing marls—the "Gypsum formation" of Blake, and the "Marl Seams" of Dr. N.'s former report, he finds extensive deposits of copper—copper schists and copper conglomer-

ate, precisely as the copper schists of Europe.' The red gypsum-bearing rocks here referred to as embracing the copper schists are probably the same seen by Meek and Hayden in Kansas between the Permian and the Lower Cretaceous, and which they were disposed to refer to the Jurassic or Triassic.

"The most important evidence however, of the age of these deposits, is in the occurrence in them of Cycadaceous plants—*Zamites*, *Pterophyllum*, &c., which are, in Dr. N.'s opinion, similar to those of the Keuper (Upper Trias) of Europe; but he reserves a positive assertion on this point until he can compare his New Mexican forms more carefully with the European species than is possible in the field.

"Dr. Newberry's route lay from Abiquia, the day after his latest date, (July 18th,) towards the country near the mouths of the San Juan, which, from all accounts, is a paradise for the geologist, but very much the reverse for other people. He hopes to exhibit his interesting collections to his geological friends in the United States by the end of October."

[*Note by the Editor of the Mining Magazine.*—The observations made by Dr. Newberry between Independence and Santa Fé, agree with those made by me in 1857. No Jurassic rocks were found upon the route as represented by Mr. Marcou, but the broad Plains were seen to be underlaid by strata of the Cretaceous period as claimed by me before the American Association for the Advancement of Science, in August, 1856; and in vol. iii. of Pacific R. R. Surveys, and the Amer. Jour. Science, Nov. 1856. Until now we have not had any evidence, by fossils, of the age of the red gypsum-bearing marls, in which Dr. N. has found deposits of copper, except, perhaps, a fossil tree, which Mr. Marcou thought very much resembled the *Pinites fleurotii* of Dr. Mougeot, which is found in the new red Sandstone of the Val d' Ajol in the Vosges. The formation was referred to the Trias by Mr. Marcou, and though the probable correctness of this opinion was allowed, the formation was described and referred to by me as the Gypsum Formation, until further and conclusive evidence of its age might be procured. W. P. B.]

Geology of the Rocky Mountain Chain near Santa Fé, New Mexico.—At the last meeting of the American Association for the Advancement of Science, a paper with the foregoing title was read by William P. Blake. The rock formations of the Santa Fe mountains were described as consisting in the central portions of gneiss and mica slate, penetrated by many seams of red or pink feldspar. Upon these formations, which may be metamorphosed Silurian and Devonian strata, Carboniferous formations are imposed unconformably. These consist of

many beds of sandstone and limestone, with thick beds of reddish or chocolate-colored sandstone at the base. The beds of limestone are not very thick, and generally contain a great number of fossils common to the Coal Measures. Beds of shale also occur, and with them thin beds or seams of bituminous coal. Beautiful impressions of ferns and coal plants were found in the shales, and specimens of them have been examined by Prof. Lesquereux who identifies two species, *Cordaites corassifolia* and *Sphenopteris latifolia*, both of which are found in the Coal Measures of Europe and America. He observes respecting Sphenopteris latifolia, that in the anthracite coal of Pennsylvania, its place is mostly with the gray ash coal, though sometimes found in the red ash coals. In the coal fields of Ohio, its place is mostly with the lowest coal, above the conglomerates. *Cordaites corassifolia* is characteristic of the Salem vein at Pottsville, of the Pomeroy coal of Ohio, and of the 4th coal of the Western Kentucky survey, and of the Illinois coal. Both plants therefore, indicate the synchronism of the Santa Fé coal with the Anthracite, the Apalachian and the Illinois coal, and place its horizon with that of the Freeport or Pomeroy coal of Ohio, or the first below the Mahoning sandstone. It thus becomes probable, that in the sandstone beds of the sections observed, we may have the equivalent of the Mahoning sandstone or "Top Rock." The occurrence of Anthracite coal was also noted.

Carboniferous strata are also found on the eastern slope of the mountains at the Great Cañon, Pecos Valley, Vernal Springs, the Puerto and about Fort Union. They are overlaid by strata which may be Permian, Triassic, and Jurassic; but no fossils were found above the horizon of the Coal Measures until the strata of the Cretaceous period were reached. This formation was first seen and recognized by fossils, on the banks of the N. fork of the Canadian River.

Volcanic rocks and overflows of lava forming mesas were seen around Fort Union and beyond on the Plains. Wagon Mound, Rabbit Ear Mound, and others appear to be of volcanic origin.

Impoverishment of Gold Veins in Depth in Australia.—By A. R. C. Selwyn, Esq., Director of the Geological Survey of Victoria. In a letter to Sir R. I. Murchison, F. R. S., communicated at a meeting of the Geological Society, Mr. Selwyn remarked, that, as to the impoverishment of auriferous veins in depth, the only evidence of such being the case in Victoria, is the great richness of the older drifts; for, judging from the large size of the nuggets sometimes found in the gravels,

compared with that of the nuggets met with in the gold-bearing quartz-veins (usually from about $\frac{1}{4}$ dwt. to $\frac{1}{2}$ an ounce, though occasionally as much as 12 ozs. or even 13 lbs.), the upper portions of the veins now ground down into gravel, were probably richer in gold (as formerly suggested) than the lower parts now remaining. As far as actual mining experience shows, some of the " quartz-reefs " in Victoria prove as rich in gold at a depth of 200, 230, and 400 feet as at the surface; the yield, however, fluctuates at any depth yet reached.

According to the author's latest observations, the gold-drifts and their accompanying basaltic lavas, are of Pliocene and Post-Pliocene age. Miocene beds occur at Corio Bay, Cape Otway Coast, Murray Basin, and Brighton; and Eocene beds on the east shore of Port Phillip, Muddy Creek and Hamilton. Two silicified fossils (Echinoderm and Coral), thought by Prof. M'Coy to be of cretaceous origin, have been found in the gravel near Melbourne.—*London, Edinburgh, and Dublin Phil. Mag.*, v. 18, 117, July, 1859.

Meeting of the American Association for the Advancement of Science.—The thirteenth meeting of the Association was held at Springfield, Mass., from the 3d to the 9th of August last, and was well attended. One hundred and eight papers were registered for reading, of which thirty-three were upon Geology and Mineralogy, a list of which is given below.

A delightful excursion was made to Amherst College, where the members spent the greater part of a day in viewing the superb collections in the different departments of Natural History. Prominent among these, is the collection of fossil foot-prints from the sandstone of the Connecticut River valley, arranged in the Appleton Hall; the Geological collections in Wood's Edifice; the Shepard Mineralogical cabinet, unsurpassed in beauty, and containing over 10,000 specimens; and the collection of Meteorites, also by Prof. Shepard, which is equalled in extent and importance, only by that in the Imperial Museum of Vienna. This collection has been in process of formation since 1828, and now contains specimens from 124 authentic localities.

List of Geological and Mineralogical Papers.

On the Origin of the Azoic Rocks of Michigan and Wisconsin. By Charles Whittlesey.

On the Drift Cavities, or "Potash Kettles" of Wisconsin. By Charles Whittlesey.

On the Occurrence of Pot Holes, (or pot-shaped excavations caused by the gyration of pebbles,) formed by the Drift Agency. By Oliver Marcy.

On the Marks of Ancient Glaciers, on the Green Mountain Range, in Massachusetts and Vermont. By Charles H. Hitchcock.

Lake and Pond Ramparts in Vermont. By Charles H. Hitchcock.

On the so-called Talcose Schist of Vermont. By Charles H. Hitchcock.

Dykes of Trachyte and Conglomerate in Shelburne, Vt. By C. H. Hitchcock.

Conglomerate, Syenite, Porphyry and Granite in Vermont. By Charles H. Hitchcock.

On the Occurrence of Bones and Teeth in the Lead-bearing Crevices of the North-West. By J. D. Whitney.

On a Frozen Deposit of modified Drift in Brandon, Vermont. By Edward Hitchcock.

On the Conglomerate near Newport, R. I., with elongated pebbles and transverse joints. By Edward Hitchcock.

On a Deposit of Fossiliferous Limestone beneath Granite and Mica-Slate in Derby, Vermont. By Edward Hitchcock.

An Attempt to prove that the younger Metamorphic Rocks have been in a plastic or semi-plastic state since their original consolidation. By Edward Hitchcock.

On the Amount and Proofs of Erosion in Vermont, with special reference to Peaks of protrusive rocks. By Edward Hitchcock.

Recent Discoveries in the Devonian and Carboniferous Flora of British America. By J. W. Dawson.

On the Vertical Planes in Bituminous and other Coals. By E. B. Andrews.

On the Terraces along the Rivers in Southern Ohio. By E. B. Andrews.

*On the Zoomorphic Sandstone of the Connecticut Basin. By Joseph Barratt.

Ornithichnites. By Roswell Field.

On the Formation of Continents and Oceans. By Joseph Leconte.

Observations on the Geology of the Rocky Mountains in the vicinity of Sante Fe, New Mexico. By William P. Blake.

* Not Read.

On some recent Determinations of the Carbonic Acid in the Waters of the Congress Springs of Saratoga. By William E. Hughes, presented by E. N. Horsford.

On the Stratigraphical Position of the Sandstone of the Connecticut Valley. By J. D. Whitney.

On a remarkable Vein of Gold in the bed of the Chestatee River, Georgia. By W. P. Blake.

The Placer Gold Mines of Georgia, and the introduction of improved methods of working them. By W. P. Blake.

Remarks on the Minerals and Ancient Mines of the Cherokee Valley, Valley River, North Carolina. By W. P. Blake.

Contribution to the History of the Laurentian Limestones. By W. E. Logan.

On Some Reactions of the Salts of Lime and Magnesia. By T. S. Hunt.

On the Formation of Gypsum and Magnesian Rocks. By T. S. Hunt.

On the Origin and Formation of Silicious Rocks. By T. S. Hunt.

The Relations of the Upper Carboniferous Rocks of Illinois to the older members of the Palaeozoic System. By J. H. McChesney.

Remarks on the Discovery of a Terrestrial Flora in the Mountain Limestone of Illinois. By A. H. Worthen.

On the Composition of Pectolite. By J. D. Whitney.

IRON.

A work of great value to the Iron interest of the United States, has appeared during the past summer, and is entitled :—

The Iron Manufacturer's Guide to the Furnaces, Forges, and Rolling Mills of the United States, with discussions of Iron as a Chemical Element, an American Ore, and a Manufactured Article, in Commerce and in History. By J. P. Lesley, Secretary of the American Iron Association, and published by the authority of the same, with maps and plates.

It is our intention to more fully notice this important volume in a succeeding number, but we present in anticipation some of the statistical summaries. These statistics have been collected by the American

Iron Association, and are presented in tables. There are now about 1200 efficient iron works in the United States, which produce annually about 850,000 tons of iron, worth some fifty millions of dollars. The production for the year 1856, was 812,917 tons, of which about one-half was anthracite iron. The whole amount of iron, domestic and foreign, consumed in the United States in 1856, is stated to be 1,330,548 tons, as follows:

	Domestic.	*Foreign.*	*Total.*
Rolled and Hammered	519,081	298,275	817,356
Pig Iron	337,154	55,403	392,557
	856,235	353,678	1,209,913

Wolfram-Steel.—F. Mayr has prepared an alloy of steel with tungsten, which appears to possess very valuable properties. Its tenacity, according to experiments made at the Polytechnic Institute at Vienna, exceeds that of all other varieties of steel hitherto examined, being equal to, on an average, 1159 cwt. to the square inch of section. The method of preparing this steel is not described. The ore of tungsten, as is well known, exists abundantly at Zinnwald in Bohemia, and has hitherto found no practical application.—*Chemisches Central Blatt, No.* 25, 1859. *Amer. Jour. Sci.*, xxviii. p. 277.

It is said that 20 per cent. of tungsten produces a mixture, which while it retains all the general qualities of steel, is so excessively hard, that tools made of it will cut, without difficulty, the hardest cast steel. Tungstate of iron and of lime are found near Trumbull, Connecticut, and near Blue Hill Bay in Maine, where sufficient for experiments, at least, could be obtained.—*Ed.*

Alloy of Iron and Silicon.—Prof. Charles U. Shepard describes* a remarkable mass of iron found in Rutherford Co., North Carolina, and supposed to be meteoric. It has the form of a fragment of pig iron, having fractured surfaces at each end, and one nearly flat side. It has evidently been in a state of igneous fusion, as the rounded side is marked by parallel grooves formed by the meeting of two opposing chilled surfaces, making what are technically known among metal founders as *cold-shuts.* It appears to have been impressed or struck while in a pasty state by some hard object on the flat side, which has thrown the surface beyond into a series of sharply defined wrinkles. The surface is brilliant, and not rusted in the slightest degree, though it has been long

* Amer. Jour. Sci., xxviii. p. 259. Sept., 1859.

exposed. The color and lustre is like that of polished platinum. It is harder than quartz, or any steel, and, according to a Sheffield cutler, cannot be tempered. It chips off under blows from a hammer, into thin scales, which may be easily crushed to powder. It is not easily acted upon by the strong acids, and does not precipitate copper from an acid solution of the sulphate. Analyses by Prof. Shepard, showed it to consist of—

Iron	84.00
Silicon	13.57

Prof. Wöhler of Göttingen, to whom a portion of the mass was sent, regards it as essentially a compound of

Iron	88.80
Silicon	11.20

"Karsten, the highest authority perhaps upon the products of iron furnaces, says, that the greatest quantity of Silicon he ever found in raw iron (pig metal), was 3·46 per cent.; and that this large proportion occurred under very rare circumstances. Stromeyer, who studied the modes of combining iron in silicon, with much care succeeded in uniting them in proportions, between 2·25 and 9·3 per cent. of silicon; but in the cases of higher proportions of silicon, he found the carbon increased also steadily in the compound to a very high percentage. It would hence appear, that the trifling amount of carbon found in the Rutherford mineral militates against the view of its furnace formation; nor is it probable that it originated in a refinery; for Karsten distinctly asserts that in that process, the silicon is mostly separated and slagged off."

The origin of this extraordinary compound, which may be regarded as a *silicon-steel*, is involved in obscurity. Prof. Shepard is inclined to regard it as meteoric, and proposes the name *Ferrosilicine* for the compound.

Native Iron.—Dr. F. A. Genth, in the Sept. No. of the *Amer. Jour. Sci.*, describes specimens which appear to be *real native iron*. The specimens are from near Knoxville, Tennessee, and northern Alabama, in thin plates not over one-quarter of an inch thick. Analysis shows it to be remarkably pure, and it is very soft. Persons who have found it in northern Alabama, suppose it to be an alloy of gold, platinum, silver, copper, etc., and sent it to Dr. Genth, with the request that he would propose a plan for the separation of these metals.

COAL.

Cannel Coal, Boone Co. Virginia.—Fine specimens of cannel coal from the Western Mining and Manufacturing Company's mines on Big Coal River, a tributary of the great Kanawha, have been presented to the Boston Society of Natural History with the following notice of the locality :

"The principal deposits are contained in two veins of an average thickness of 40 inches ; they lie on the mountain, 140 to 160 feet above the level of the valley, and about 20 feet apart ; the inclination of the deposits being only 1 foot in 70 affords sufficient facilities for drainage. The deposit is columnar in its structure, with a horizontal lamination admitting of cleavage both ways, so that it is easily mined by means of the pick and wedge. For purity, it is probably unsurpassed ; it is in demand chiefly for the manufacture of coal oil, though it is excellent as fuel."

Coal-bearing Rocks in Maine.—At the June meeting of the Boston Society of Natural History, Prof. Rogers exhibited specimens of the supposed coal-bearing rocks of Maine, in which was an impression closely resembling *Cyclopteris Hibernicus*, so common in Great Britain. He was of opinion that these rocks of Perry, Maine, belong to the sub-carboniferous series so extensive in Ireland—they are abundant not only in New Brunswick and Nova Scotia, at the depth of several thousand feet, (and containing the famous asphaltic coal,) but throughout all the Apalachian chain. They are below the productive coal series, yet in some cases they do contain workable coal seams, two, three, or five feet in thickness.—*Proc. Bost. Soc. Nat. Hist.*, vii. 86.

Bellingham Bay Coal.—The largest coal dealers in San Francisco, Messrs. Sinclair & Williams, have contracted with the Bellingham Bay Company for 10,000 tons of coal, to be delivered during the ensuing ten months, at $12 50 per ton ; and the same dealers desire to contract for 4,000 tons. The Pacific Mail Steamship Company have also made propositions for a large amount for their steamers.—*Olympia Pioneer.*

Sinking for Coal at the Shireoaks Colliery, England.—In two shafts sunk for the Duke of Newcastle on the north-west side of his estate of Worksop Manor, the first seam of coal 2 feet thick and of inferior quality, was cut at a depth of 264 feet. 12 feet below this is a compact sandstone 66 feet thick. The sinking through this rock occupied 20 months ; each pit made 500 gallons of water a minute, which was stopped in detail by cast-iron tubing. The pressure from gas at the bottom of this thick rock was at times as high as 210 lbs. per square

inch, but became 196 lbs. Shales with coal seams and bands of iron-stone, all thin or of inferior quality, were met with in the next 510 feet. At a depth of 1038 feet the first thick coal was cut, and found to be 4 feet 6 inches thick, and of good quality. At a depth of 1530 feet the "Top Hard Coal" was cut, and found to have a thickness of 3 feet 10 inches. The sinkings were commenced in March, 1854, and perseveringly continued until their completion on February 1st, 1859.—Abstract from *Proc. Geol. Soc., June* 1859. *Phil. Mag.*, July 1859.

Expenses of the Transportation of Coal.—The Miner's Journal of Oct. 1st says:—"Last week we gave some figures showing that coal can be carried direct from Mount Carbon to New York at a cost of not more than two-thirds of a cent per ton per mile, including cars, motive power, and also the maintenance of the road. We are satisfied that when the trade reaches one million of tons by this route, it can be carried as far as Easton at a half cent per ton, and from Easton to New York or Elizabethport, at an expense not exceeding two-thirds of a cent per ton per mile.

On page 38 of the Report of the Managers of the Philadelphia Reading Railroad, dated January, 1859, the actual average expense of transporting coal trains, which averaged 421 7-100 tons of 2,240 lbs. is put down at 27.74 cents per ton, which is a fraction over a quarter cent per mile. On page 42 of said Report, the whole expenses of transporting a ton of coal from Mt. Carbon to Port Richmond, including maintenance of road, cars, office expenses and salaries, is put down for 1858 at only 49.81 *cents per ton for the* 93½ *miles;* which is only a shade over a half cent per ton per mile.

The expenses on the Lehigh Valley Railroad last year, for a coal business of 471,029 tons, was 33 cents per ton for 45 miles, which is about two-thirds of a cent per ton per mile.

By a Report published in the *Baltimore Exchange* of the 15th ult., made by the City Directors of the Baltimore and Ohio Railroad, in reply to a resolution of inquiry made by City Councils, relative to the cost of transporting a ton of coal from Piedmont to Baltimore, the actual expenses are given as follows:

Motive power and train expenses for hauling one ton Coal............	71.7	cents.
Repairs of Coal cars..	17.7	"
Maintenance of railway, Bridges, &c....................................	49.4	"
Total expenses..	$1 38.8	

Distance 206 miles, which is only about two-thirds of a cent per ton per mile.

FROM CUMBERLAND TO BALTIMORE.

Motive power and train expenses	64.7 cents.
Repairs of Coal cars	15.5 "
Maintenance of railway, bridges, &c	43.2 "
Total expenses	$1.24.3

Distance 178 miles, a shade over two-thirds of a cent per ton per mile over a road which is undulating the whole distance, and has heavier grades against the trade than any other coal road in the United States traversed with locomotives. To show the character of these grades, we append a note addressed to a citizen of our Borough by Mr. Woodside, Superintendent:

"TRANSPORTATION OFFICE, April 6, 1856.

"DEAR SIR:—The maximum load carried up the steep ascending grades of the Baltimore and Ohio Railroad, (Coal,) by Ross Winan's engines, is, upon Cranberry Grade, 11 miles, 116 feet per mile, 9 cars of 10 tons contents, and 6 tons weight. Upon Parr's Ridge, plane No. 4, 2½ miles, 85 feet per mile, 18 cars of same sort.

"W. S. WOODSIDE, *Supt.*"

Coal Trade for 1859 *to Oct.* 1.—The following table, taken from the "Miner's Journal," exhibits the Coal Trade for 1859, up to Oct. 1, compared with the corresponding period in 1858:

	1858.	1859.	*Increase.*	*Decrease.*
SCHUYLKILL—Railroad	1,216,432	1,274,129	57,697	
" —Canal	895,576	952,602	57,026	
Lehigh Valley—Railroad	359,317	434,236	74,919	
" " —Canal	625,733	728,275	102,542	
Scranton South	380,084	449,695	69,611	
" North	108,213	145,191	36,978	
Penna. Coal Co	463,874	528,069	64,195	
Delaware and Hudson Co	250,003	417,787	167,784	
Wyoming—Canal South	....	284,229	120,000	
" " North	....	39,045	....	
Shamokin Region	77,872	114,797	36,925	
Total Anthracite	4,377,104	5,329,945	787,677	
Lykens Valley Coal Co	50,981	37,840	....	13,141
Short Mountain Co	34,170	43,857	9,687	
Trevorton Coal	71,866	89,093	17,227	
Broad Top	71,406	90,625	19,219	
Cumberland Coal	468,070	370,256	....	97,814
Semi-Anthracite & Bituminous	696,493	631,671	46,133	110,955
Add Anthracite	4,377,104	5,329,010	787,677	
Total	5,073,597	5,960,681	833,810	

COPPER.

Lake Superior.—The late reports from the Phœnix mine are flattering. A new vein has been discovered on the east bank of Eagle River, opposite No. 2 shaft, which averages from four to six feet in width, and affords considerable native copper, as well as the ores. The workings at No. 2 shaft have attained a depth of 150 feet, and a cross-cut has been driven under the ancient bed of the river. It is intended to intersect the newly-discovered vein by this cross-cut.

At the Isle Royale mine, Hodge's stamps were tried with success.

Mining operations generally are active. On Keweenaw Point the discovery of the "ash-bed" has given a new impetus to operations. The discovery of the Minnesota conglomerate belt on certain other properties in the Ontonagon region has given a fresh start to mining labors there. The Canal Company's discoveries, the continued increase in richness of the Pewabic lode, and the researches for this on other locations, promotes activity in the Portage Lake district.

The editor of the Cleveland *Herald* has been making a tour of observation through the Lake Superior Region, and has published a series of letters, from the last of which we extract the following:

"The greatest start has been in the Portage Lake district, where the mines have recently been worked in the north and south veins with astonishing success. Copper has been found in large masses in these veins, and, contrary to previous theories, these lodes appear to afford every prospect of continuing to send up large products."—*Compiled from Portage Lake Mining Gazette.*

The Lake Superior Miner furnishes the following information relative to mining matters in the Ontonagon district:

"At the Bohemian's Piscataqua mine, the most eastern one now operating, they are working but two parties of men—one on the south side adit running north, which is now in some 100 feet, and the other on the western part of the mine, at the same point mined on by Mr. Dickinson, some years since. Here they are finding some copper, but have found nothing in the adit worthy of note.

"The Toltec has but few men in the mine at present, the attention being turned mainly to explorations in the low lands near the plank road, where they hope to find the Minnesota formation. They have sunk three shafts, none of which have yet reached the rock, though the south shaft is down 40 feet, at which point they struck water and quicksand, obliging them to abandon the point.

"The usual show of copper is visible at the Aztec, though the mine force is but six tributors, two of which have taken out some two tons of strong mass and barrel copper the past month.

"The Adventure is not working a large mine force at present, though the 'pitches' are looking well, and the stamp machinery continues to operate with entire satisfaction.

"The Nebraska is taking some very clever little masses, from 1500 to 2000 pounds weight, from the stopes in the X level, and the vein is showing well in sinking from the X to the XX level. The succession of copper courses known to exist on all the mining properties on the right, as above named, from the Nebraska on the west to the Pisquataca on the east, each dipping at a greater angle from a perpendicular as they go south, will certainly yet lead to important discoveries in the future.

"At the Superior, the first and second levels from the Flint Steel are still being driven west from the north and south line between these mines, the second or lower level having reached a distance of some 100 feet from the line. The vein is not large, averaging perhaps a foot in width, but its characteristics are those of the mines on that part of the range, and it is now producing stamp and barrel copper, with occasionally a small mass by way of variety.

"At the Rockland, it may be truly said that 'a change has come over the spirits' of holders. On Wednesday of this week they raised some nine tons of mass copper, and from the amount still exposed in the XL level, they can do so for several days, and 700 feet of strong vein from east of No. 3 to west of No. 1 shaft, will still be comparatively undisturbed. The mine is also looking well at several other points, so that no fears whatever need be entertained that the present net product of $5000 per month will not increase, with her probable accession to the monthly product of copper."

The Portage Lake Gazette gives the following:

"PEWABIC.—The operations at this mine are going on finely, and the underground prospects were never more promising. The following was the yield in August:—

	lbs.
Kiln copper	86,413
No. 1 stamp copper	35,315
No. 2 stamp copper	50,098
No. 3 stamp copper	4,205
Mass copper	7,554

—making in all the handsome product of 188,535 lbs., or 91 tons and 1,585 lbs.

"COPPER FALLS.—The whole product of this mine has been as follows:

	1858.	1859.
May	℔ ...38,399	56,292
June	℔ ...37,068	88,371
July	℔ ...61,026	72,117

"The shipment of copper, 230 tons to July 25, exceeds the whole shipment this year.

"HANCOCK.—Work was commenced on this location last June, and the results thus far have been all that could be expected. When they get the mine opened a little, and the stopes set out in working condition, we expect to see mining done at a profit. The Company are going to erect stamps, which will greatly augment their yield.

"DACOTAH.—At this mine they are prosecuting their explorations with vigor, before the wet weather sets in, leaving the discoveries they have made until Fall, when they will, in all probability, do some mining.

"ISLE ROYALE.—The present condition of this mine is good with flattering prospects. The new openings are quite promising, and bid fair to give a reasonable yield of copper. The following is the yield for the month of August:

Barrel work, ℔	26,467
No. 1 stamp work, ℔	8,446
No. 2 stamp work, ℔	5,290

—in all 20 tons 203 lb. copper.

"FRANKLIN.—This mine never looked better than it does at present. The new openings are very rich, and yield well. The amount of copper taken out in August was:

Kiln, ℔	48,286
Mass, ℔	4.728

—total, 53,014 lb., or 26 tons 1214 lb. The yield for this month will be much larger than that of August.

Origin of Native Copper and Silver of Lake Superior.—At the March meeting of the Boston Society of Natural History, Dr. Charles T. Jackson alluded to the manner in which the native copper and silver of Lake Superior are formed. It is his opinion that they were deposited from their chlorides "in contact with iron, as he had explained at a previous meeting in regard to gold. It is well known that at the junction of the trap with the metalliferous vein, the rock becomes brown from the oxydation of the iron. When once deposited, it continues to be formed by the operation of the same causes; and when the copper is deposited, pure metallic silver, formed from the chloride, is plated upon it; the two metals chemically pure are in contact yet unalloyed. The old theory of the formation of these deposits from acid solutions is unsatisfactory, and unable to account for the absence of the ordinary lime salts."—*Proc. Bost. Soc. Nat. Hist.*, vii. 31.

Copper Schists and Conglomerate in New Mexico.—It will be seen by reference under the head of Geology, that Dr. Newberry has

recently discovered extensive deposits of copper in New Mexico, in the formation which is probably of the age of the Trias. The deposits resemble those of the copper schists of Europe.

Whitneyite, an Arsenid of Copper.—Dr. F. A. Genth* thus describes a new mineral from Lake Superior: "Massive, structure crystalline, finely granular; hardness = 3.5; specific gravity at 16 Cels. 8.408. Lustre metallic; color reddish white (about that of the new American cent, or of an alloy of equal quantities of copper and silver). Admits of a fine polish, but soon tarnishes." * *

"Before the blowpipe it fuses readily, and gives off the odor of arsenic. Insoluble in chlorhydric acid: soluble in nitric acid. Composition: $Cu._{18}$ As. Analyses:

			Calculated.
Copper	88.07	88.19	88.37
Arsenic	11.81	11.41	11.63
Silver Insoluble	0.33	0.47	
	100.21	100.07	100.00

"It occurs coated with red copper and a copper salt resulting from its oxydation, probably olivenite. One boulder of forty pounds' weight has been found at the Pewabic mine, Houghton County, Michigan, and was mistaken for silver." * * *

"In its chemical relations it is of considerable interest, because it is another example in which a multiple of six equivalents of copper combines with one of arsenic, forming with domeykite and algodonite a beautiful series of arsenids of copper, viz:

Domeykite	Cu_6 As.
Algodonite	Cu_{12} As.
Whitneyite	Cu_{18} As.

The mineral is named in honor of Professor J. D. Whitney. Dr. Genth has since referred to the fact that Dr. Jackson observed a mineral composed of arsenic and copper in 1848, which may have been the same as this species.

A New Sulphid of Copper and Lead—Alisonite.—Mr. Frederick Field describes a new sulphid of Copper and Lead which has the following composition:

Copper	53.63
Lead	28.25
Sulphur	17.00
	98.88

* Am. Jour. Sci. xxvii. No. 81, p. 400. May, 1859.

Corresponding to 3 Cu. $_2$ S. Pb S. which requires Cu. 53.33, Pb 28.88, S 17.77.

The name *Alisonite* is proposed for this mineral in honor of R. E. Alison, who has spent several years in developing the mineral wealth of Chile.*

Statistics of Copper Mines.—From *Gryll's Annual Mining Sheet*, the Cleveland *Herald* condenses the following interesting statistics of the copper mines of Cornwall, for the year ending June 30th, 1859:

About 120 mines in Cornwall sent copper to the "ticketing," or sale, during the year, making a total of 183,944 gross tons, of 21 cwt. each. The mine sending the largest quantity was the "Devon Great Consols," which turned out 23,648 gross tons. The "United Mines" turned out 9815 tons; "West Basset" 7036 tons, and "West Seaton" 6025. Five other mines exceeded 5000 tons each, three over 4000 tons each, six over 3000 tons each, seven over 2000 tons each, twenty-one over 1000 tons each, and the balance ranging from 120 to 900 tons each.

The highest average price for ore sold during the year was that of the "Grambler and St. Aubyn" mine, £17 2s. The total amount received for the ore sold was £1,079,075 17s., or over five and a quarter million dollars. The average price of the ore sold was £5 17s 6d.—The ore produced 11,888 tons fine copper, the average standard price of which was £133 6s. The average produce of the ore was 6⅝ fine copper.

GOLD.

Hydraulic Hose Mining in Georgia.—In Lumpkin county, Georgia, two great enterprises for supplying water to the gold deposits are in progress. The canal of the Chestatee Hydraulic Company, about twelve miles in length, is designed to convey the water of the Chestatee River to the placers in the vicinity of the Loud deposit. It is not quite complete, though experimental washing with one pipe was commenced in May at the upper margin of the gold-belt.

The Yahoola River and Cane Creek Hydraulic Hose Mining Company, organized in Boston, is now constructing a canal about twelve miles long, from the Yahoola River to Dahlonega. This canal is six feet wide at the top, five at the bottom, and three feet deep. The ditching

* Am. Jour. Sci. xxvii. No. 81, p. 387.

is nearly completed, and has a total length of 58,250 feet. Whole length of trestles 6220; flooring 620, cuts or excavations 1,872 feet. The greatest length of connected trestle work is 3400 feet, of which the highest point is not over 55 feet. The highest trestle is 238 feet high in the centre, 1480 feet in length, and is to be built across the valley of the Yahoola, about two miles from Dahlonega. The placers which this water will command are in the vicinity of Dahlonega, and are regarded as fully equal to any in the Georgia gold belt.

Rich Gold Vein in North Carolina.—In Towns County, North Carolina, near the Georgia line, a remarkably rich gold-vein has lately been opened by Allan P. Cunningham, Esq. It is a ledge of white quartz varying from one to two feet in thickness, comparing in this respect, and in its richness in gold, with the best California "ledges." Gold in coarse particles is found in almost every part of this quartz, but is particularly abundant along the seams or walls. Many of the rocks are remarkably rich and beautiful. A mill with twenty stamps is in the course of erection, and is to be driven by water from Brasstown Creek.

Gold in Alabama.—Recent discoveries of gold are reported to have been made in Tallalega County, Alabama. It is found in veins and in stream deposits.

Southern Gold Company.—A company with the foregoing title has been organized in Boston to work the gold veins upon the Singleton or Capps lôt, No. 792, near Dahlonega, Georgia. This lot contains 40 acres, and is traversed by Cane Creek, which affords water power for driving a mill. A stamping mill of twelve stamps is being erected, and is now nearly complete. The lot is traversed by one or more narrow veins bearing coarse gold, and it is proposed to mine, in part at least, by the aid of water under pressure—the Hydraulic method of California. The Company have secured the services of Col. Hezekiah Kelley to superintend the construction of the mill; he having just completed one for the Georgia Gold Company, on the adjoining lot. A pamphlet containing a prospectus of the Company, with a descriptive Report of the lot, by Wm. P. Blake, and extracts from reports made by Dr. Charles T. Jackson and James T. Hodges was issued in Boston in May last. From this we learn that "the Company is incorporated under the laws of the State of New York. The Capital Stock is divided into 100,000 shares of the par value of $5 00 each, with the right to increase to 200,000 shares additional, if at any time hereafter the Com-

pany may deem it advisable to add thereto by purchase of other mines."

Gold Nuggets in Georgia.—Mr. Rufus Asbury, who for a year past has been working over the refuse gravel piles of the old and famous Loud gold deposit in Lumpkin Co., Georgia, has recently taken out a lump of gold weighing 163 pennyweights. In 1856, one was found which weighed 177 dwts., and the largest ever found there weighed 737 dwts. This is one of the most interesting and rich deposits ever worked, and appears to have been formed by the accumulation of fragments of a very rich vein, not over an inch or two thick. The gold from this locality contains a large portion of silver, and averages from 830 to 880 thousandths fine.

Gold in Vermont.—Gold has been taken out in considerable quantities in Windsor County, Vermont, during the present summer. It is obtained from placers or deposits by sluicing or washing in the ordinary way. It is said that over 5000 dollars worth has been mined, one man having dug 1200 dollars worth. About 40 persons have been and are still employed, and generally make fair wages. According to the *Bellows Falls Times* [July], Mr. Hankerson never averages less than $5 a day to each hand. On Thursday of week before last he got $20, on Friday $30; Saturday $40; Monday $25; and Tuesday $25, and some of the time with only one hand. This makes $140 in five days. On Friday, July 8, Sawyer and Eddy got $40. On the same day they found one piece valued at $12.

Rocky Mountain Gold Mines.—Reports from the Pike's Peak Gold Region continue to be favorable, and there is without doubt a broad region in that part of the Rocky Mountain chain, rich in gold, not only in placers but in veins. Rich quartz leads have been prospected, but are temporarily valueless for want of machines for washing, for which there is a great demand. Several have been ordered, and are on the way from the States, and some of rude construction are being operated by ox power. Messrs. Conklin & Co. have completed the foundation of a quartz mill in Gregory Valley, which it was expected would be in operation by the last of September, and crush some fifty tons of quartz a day. Much of the most profitable mining in Gregory valley was upon the softened or decayed portions of the quartz leads, which yielded enormously until the harder portions of the leads were reached, where it was not possible to extract the gold by mere sluice-washing, and mining was discontinued until machinery for mining and crushing could be erected.

Frazer's River Mines.—Intelligence from the mining region of British Columbia is more cheering than it has been for several months previously, and is likely to continue so as the river recedes. From the present time until cold weather sets in, any one accustomed to mining labor can make from \$5 to \$8 a-day on the Lower and Middle Frazer, and many are returning to British Columbia from Oregon and Washington.—*Gazette, Aug.* 6.

The miners at McDonald's Bar, near Fort Alexander, are represented, in the Victoria *Colonist*, to be making \$15 or \$20 a day. Above and below the cañon the miners are doing well.

Quartz Mining in California.—Late accounts from Grass Valley are not as favorable as usual. Several of the leads as they are worked deeper do not yield as well as at first near the surface. The Albion Ranch Mill, which paid \$40,000 clear a month for a long time, has stopped operations, the rock lately mined not paying, it is said. The proprietors are about to sink some seventy feet further.

A rich quartz lead, now called the Grizzly Mine, has recently been opened in Tuolumne County, which yielded 558 ounces of gold, worth about \$7000, in one week.

It is reported that Col. J. C. Fremont is taking about \$5000 per week out of his mines at Mariposa.

According to the Mariposa Star, a rich pocket on the vein near the Bondurant Mill, yielded in six days work of Mr. Howell and the Linn brothers, 101 lbs. 9 oz. and \$12 in coarse gold, all of which was pounded out in a hand-mortar. This is equal to 1221 ounces, which at \$17 an ounce amounts to \$20,769. The fine gold contained in the siftings will probably amount to over \$3000 more.

The San Gabriel Mines in the gold region of the Bernardino Mountains—the oldest mines in California—are still being worked successfully according to the Los Angeles Star, which says:

There are about three hundred men at work in the cañon, all of whom are represented as doing well. There is a good deal of trouble in getting the claims into working order, and those afraid of work should not go there; but the industrious men who have taken up the claims are well remunerated for their labor. We have been informed that two men belonging to the second Mexican company, of which Rafael Gonzales is president, took out, in two days' washing, \$90. This was done with the common wooden bowl, such as is usually used by Mexicans. A rich quartz lead has also been discovered.

MISCELLANEOUS.

Silver Ore in the Sierra Nevada, California.—The discovery of a vein of rich silver ore in the mountains between Honey and Mud Lakes in California, is reported in the Shasta Republican. The vein is south of Mud Lake and runs in a direct north and south line. In some places the lead is from ten to fifteen feet wide. It can be readily traced. Where the ore does not crop out, its presence is readily determined by the color of the ground. Some of the quartz containing the silver has been brought to Shasta, and assayed by Lewin & Baehr. The yield was at the rate of 164 ounces to the ton. The metal is represented to be of the finest quality. The ore resembles that found in the celebrated Arizona mines. The mine is situated about 65 miles north-east from Honey Lake, and is accessible by a good wagon road. Claims have been taken up by the discoverers and preparations made for working.

New Quicksilver Mine in California.—The correspondent of the N. Y. Times under date of July 25th states:

"A new and valuable quicksilver mine was formally inaugurated with religious ceremonies (an old Spanish custom) a few days ago. This mine is situated twelve miles south from San José, in the cañon of the Sierra Azul (Blue) or Santa Cruz mountains, through which flows the Capitancillos creek. The mine was discovered by a party of miners under a Mr. Laurencel, in January last. During the temporary absence of Mr. Laurencel, on a visit to the East, last Spring, it was worked upon a very small scale, but to a sufficient extent to test its value, and leave no doubt of its being sufficiently rich and extensive to repay amply the expenditures necessary for opening and properly working it. On the return of the proprietor, about two months ago, operations were commenced on a larger scale, and preparations made for the erection of furnaces, opening roads, etc. There are now fifty men employed in working the mine, and about thirty in putting up the smelting works and other necessary structures. At present the ores, which are rich and easily excavated, are carried down on mules from the mouth of the mine to the flat, a distance, as before stated, of a quarter of a mile. The smelting will be commenced about the 15th September next."

Tin Ore in Greenland.—J. W. Tayler, Esq., F. G. S., in a communication to the Geological Society of London, describes tin veins as occurring at Evitok, near Arksut, Greenland.

These tin veins, of which there are about twenty, extend over an

area of about 1500 feet in length by 80 in breadth, and run in various directions, some east and west, others north-east and south-west, and others north and south. They vary from 10 inches to ¼ of an inch in width; in the largest veins the tin ore occupies about one inch of one side of the vein. The veins nearly all occur in a great vein of feldspar and quartz with ores of lead, copper, zinc, iron and molybdena, associated with cryolite, fluor-spar, zircon, &c.—*London, Dublin & Edin. Phil. Mag.*, vol. 17, p. 307.

Oil Springs.—Mr. E. L. Drake, the lessee of the Pa. Rock Oil Company, has recently in boring for salt or oil to a depth of 71 feet, near Titusville, Pa., struck a fissure in the rock charged with water and oil, yielding 400 gallons of pure oil every 24 hours. The oil and water are pumped into a vat; the oil rises to the surface, and the water runs out at the bottom.

Salt Springs in Nebraska.—Mr. A. J. Davis, formerly of Illinois, but now of Nebraska, has produced a specimen of salt manufactured there, that is destined to work a revolution in the salt trade. The water from which the salt is made, is obtained from two large springs, and we are informed that sufficient quantities can be obtained to supply the whole country with this indispensable article. Three pounds of salt can be made from two gallons of water, and, in addition to this fact, the quality of salt is pronounced, by competent judges, to be 20 per cent. better than that of Syracuse or Kanawha. These springs are located on a stream called Salt Creek, thirty-five miles from Plattsmouth, Missouri. Two companies, with a capital of $100,000 each, have been organized, and we may expect, in a year or two, to receive our supplies of salt from the West instead of the East. Such is the desire to obtain shares in these companies, that in some instances they have been sold at an advance of four hundred per cent.—*Gate City.*

Increasing the Power of Locomotives by Magnetizing the Wheels.—At the meeting of the American Association in August, Mr. Edward W. Serrell gave the results of his experiments in magnetizing the driving wheels of Locomotives, so as to increase their adhesion to the rail, and thus increase their effective force without adding to their weight, which is always so destructive to the rails and ties. By making electro-magnets of the wheels, Mr. Serrell states that he obtains an increased adhesion of over seventy-five per cent. He describes the helix and the results as follows:—

"The lower segment of the wheel is surrounded by a helix of copper-

wire, through which the wheel revolves, and, contrary to the generally received opinions, it was found that upon curving the helix into a segment, the radius of which is equal to the diameter of the wheel, the point of greatest magnetic effect coincided with the contact of the wheel and rail.

"The wheels magnetized in the experimental trial were four and a half feet in diameter, and weighed about eleven hundred pounds each.

"On a very slippery rail 19 lbs. of steam per inch slipped the wheels without magnetism; under the same conditions 35 lbs. were required to slip them when magnetized.

"On a very clean rail, and every thing being favorable, 50 lbs. were required without any magnetic effect, and 88 lbs. when magnetized.

"The helix was made of No. 8 copper wire in one strand, 2,700 feet in length, and laid in 288 turns, insulated with cotton and marine glue, and covered with India-rubber."

These are not only very interesting results in electro-magnetism, but a most important and beneficial practical application of it. Experiments upon Locomotives since the above was written fully sustain the statements. In one instance the Locomotive on the N. Y. Central R. R., weighing 22 tons, drew more on a slippery rail than another engine weighing 38 tons. Mr. Serrell is well known as the engineer of the Great Suspension Bridge across the Niagara River at Queenstown, and other important public works.

Bornite, Telluret of Bismuth.—Dr. Charles T. Jackson has analyzed the "Tetradymite" of the Field gold vein, near Dahlonega, Georgia, and finds it to have the following composition:

Bismuth,	(BO. 0.88)	0.7908
Tellurium,	(Metallic)	0.1800
Selenium,	(Ba O + Se O^2 0.42)	0.0118
Gold (mechanically mixed in fine scales.)		0.0060
Loss,	. . . .	0.1114
		1.0000

Which is nearly that of the Brazilian mineral analyzed by Damour, and named *Bornite.* No sulphur was found.—*Am. Jour. Sci.*, xxvii. p. 367.

Solder for Aluminium.—M. Mourey has described to the *Société d'Encouragement* in Paris, a process which he invented for soldering aluminium. He adopts an ingenious device for this purpose. In the ordinary way to solder two metals or two pieces of the same metal, all that is necessary, after having prepared the two surfaces which are to be

brought together, is to cover them with solder, and to heat them. This mode of proceeding does not succeed with aluminium. M. Mourey prepares each of the two surfaces with a first solder, an alloy of aluminium and zinc, and then interposes between the two surfaces thus prepared another alloy richer in aluminium. In this manner, the first alloy adheres to the aluminium itself, and the second alloy to the first, and thus a perfectly solid and continuous whole is obtained. The surfaces to be soldered are prepared by being smeared with a mixture of turpentine, balsam of copaiva and lemon-juice, then placed on hot coals, and into the parts where the soldering is to take place, the flame of a gas lamp or self-acting blow-pipe is directed. Small pieces of an alloy of six parts of aluminium and ninety-four of zinc, are brought into contact with the prepared surfaces; these melt and adhere to the surfaces, being pressed against them by small tools made of aluminium. This operation is a rapid one; it requires, like any other soldering of this kind, a certain amount of care, but not more than in the hard soldering of copper. In each case a skill and knack are necessary on the part of the workman, as well as care in adjusting the temperatures, for the melting points of aluminium and zinc are scarcely 100° apart, and there is a fear whilst melting the solder lest the article itself should melt at the same time.

When the two surfaces have been thus prepared they are brought together, and kept in contact by iron wire, pincers, etc., as in ordinary soldering; pieces of the hard solder, 80 of zinc 20 of aluminium, are then placed at the points of contact, and the heat from a lamp is then applied, and the second solder melts, runs in, and adheres to the two layers of soft solder, and thus forms a strong joint. The articles thus prepared are sufficiently strong to allow of their being re worked, and the joints will bear filing.—*Jour. of Arts*, vii. 331, p. 293.

Cost of Tunnelling in the Alps.—The expenses incurred up to the present time for the tunnel under the Alps at the Col de Frejus, says a late English paper, amount to 5,000,000 francs for a length of 613 metres which have been pierced—358 on the Piedmontese side, and 255 on that of Savoy. The cost of the tunnel heading (full width and height of course) has been up to the present time, 3,156 francs for the lineal metre; say $600 a yard.

Gold and Silver transported over Panama Railroad.—During the four years ending December 1, 1858, the amount of specie transported over the Panama Railroad, was over $200,000,000. The precise sum

was as follows:—Gold, $171,157,421 28; Silver, $29,902,793 49. Total, $200,561,214 74. Consigned to the United States, $135,098,-87; to England, $65,426,120 87. The silver was exclusively for British account, having been brought to Panama from South America and Mexico, and most of the gold shipped to the United States found its way ultimately to the Bank of England.—*Letter of David Hoadley, Esq.*

Sulphur.—The Yreka Union of California, acknowledges the reception of specimens of lava and sulphur from the top of Mount Shasta.

Preserving Stone and Iron.—One of our foreign exchanges states, that parts of the Palace at Westminster, which were fast going to decay, have been restored by the application of the silicate of soda solution, washed after drying with dilute muriatic acid, so as to render the soda soluble, when it washes off with rains, etc., leaving behind it an indestructible coating of pure silica, or flint, on which not even the hardest scrubbing with wire brushes and water makes any impression. Applied to iron in a somewhat similar way, it forms a coating that will preserve the metal from rust. The roofs of the Clock and Victoria Towers, to which it has been applied, are bright and clean as when emerging from the foundry. It adheres to a metal surface so tenaciously, that in attempting to remove it the chisel chips off the iron with it. It appears indestructible by the elements, and is uninjured by long immersion in sulphuric acid.—*Am. Railway Times.*

BIBLIOGRAPHICAL NOTICES.

A new work on Metallurgy is announced as forthcoming from the press of John Murray, Albermarle street, London, entitled, *Metallurgy, or the Art of extracting Metals from their Ores, and adapting them to various purposes of manufacture.* By John Percy, M. D., F. R. S., Lecturer on Metallurgy at the Government School of Mines. The publishers state in their announcement that, "The work will embrace the whole subject under the following heads:—1st. General principles of the Science. 2d. Fuel. 3d. Materials used in Metallurgical Constructions. 4th. Special Metallurgical Processes, including Assaying. The author has received from British smelters an amount of willing co-operation for this work, which he could never have anticipated. Original drawings of Furnaces, &c. Descriptions of Processes and de-

tails of Expenditure have been freely communicated with full permission to publish them. In return, the author hopes to present to the British smelter, a complete account of the present state of metallurgy abroad. Almost every important process has been in a greater or less degree re-investigated by the author; and all the experimental results which it has required many years to obtain, will be embodied in this work. The illustrations, it is believed, will be sufficiently distinct and accurate to admit of their being used as working drawings."

Traité de Metallurgie Theorique et Pratique, par M. L. E. Rivot, *Ingénieur des Mines, Professor à l'Ecole des Mines.* 8vo. with plates. Paris, 1859. The first volume of this work upon Metallurgy has appeared, and will shortly be followed by the second. The first volume relates to the treatment of copper and silver ores, and is complete in itself. The ores of copper and the different metallurgical processes for their reduction, are considered in the first four chapters. The fifth is devoted to a description of the processes for the extraction of silver.

L'Aluminium, its Nature, Manufacture and Uses.—By H. St. Claire Deville. 8vo. pp. 176, with plates. Paris, 1859.

MINING REPORTS RECEIVED.

Sonora Exploring and Mining Company. Report of Frederick Brunckow, and a Letter from Herman Ehrenberg, with an Appendix. 8vo. pp. 47. Cincinnati, 1859.

Santa Rita Silver Mining Company. First Annual Report to the Stockholders. Cincinnati, 1859, 8vo. pp. 36.

Charter and By-Laws of the Arizona Land and Mining Company, with a statement giving the particulars of the estates of the Company, and of the mineral regions in the territory of Arizona. By John R. Bartlett, Secretary of the Company. 8vo. pp. 26. Providence, R. I., 1859.

Charter and By-Laws of the Sopori Land and Mining Company, with a statement giving the particulars of the estates of the Company, and of the Mineral Regions in the Territory of Arizona. By John R. Bartlett, Secretary of the Company. 8vo. pp. 26. Providence, 1859.

The Silver Mines of Setentrion, Mexico. Large 8vo. pp. 40. New York, 1859.

Report on the Mount Pisgah Copper Mine, Georgia. By Charles Upham Shepard, M.D. L.L.D. 8vo. pp. 8. New Haven, 1859.

Prospectus of the Southern Gold Company, with the Report of William P. Blake. 8vo. pp. 15. Boston, May, 1859.

COMMERCIAL ASPECT OF THE MINING INTEREST.

There is no excitement in the market for mining stocks, though companies are constantly forming to work the various copper, gold, silver, and other mines brought to notice within the past few years.

The Minnesota Mining Company have declared a dividend of $4 per share, payable on the 1st of November. The sales of last year's product being now closed, the ascertained net earnings, or profits, for 1858 (estimated in last report at $210,000) are $206,020, the whole of which has been realized in cash. The dividend now declared, with that paid out in May last, makes the sum of $180,000 divided among the stockholders from the above amount, leaving a surplus of $26,000 in and for the benefit of the present year's business.

We are informed that the shareholders of Isabella, East Tennessee, Calloway, and Cherokee Copper Companies are requested to surrender their stock in exchange for stock in the "Illinois Consolidated Mining Company," at the office of that Company, No. 51 Exchange place. The above three mines have produced, in the last four months, 2,181 tons ore, producing 266 tons of fine copper.

Late intelligence from Arizona states that a ton of silver was at El Paso awaiting shipment to the Eastern States. Two hundred pounds of the precious metal was on its way to the Philadelphia mint, in charge of Capt. Smith, of the Overland mail line. This speaks well for the productiveness of the Arizona mines.

We also learn that the Sonora Exploring and Mining Company, have nearly ready for shipment for the Heintzelman mine two engines of 25 horse-power each, which, should they reach the mine in safety, will be the first introduction of steam-power into that mining region.

We give the following synopsis of the market for mine products:

Coal.—We quote Anthracite per cargo at $3 20 *a* $4 40, and from yard at $4 10 *a* $4 75 per ton.

Copper.—Sheathing Copper, small lots, at 26 *a* 27c per lb. 6 mos. Ingot Copper 23 *a* 24 per lb.

Iron.—There is very little movement in the market; $23 *a* 23½ for No. 1 Anthracite; $22 *a* 22½ for No. 2. Scotch pig 23 *a* 24, and boiler iron quiet; a sale of 50 tons wire billets was made at $85, 6 mos.

Lead.—No sales of pig have come under our notice. Lead pipe and sheet lead are selling at 7¼ per lb.

For the present prices of stocks in the market, the reader is referred to the *American Share List* on the following page.

AMERICAN MINING SHARE LIST.

This list we shall extend from time to time, until it includes, so far as practicable, every existing Mining Company whose stock is offered, or is likely to find sale in the market. As it is desirable that it should be correct, we solicit the co-operation of officers of Mining Companies.

Mining Company.	Office at	Location of Mining Operations.	Shares.	Paid in.	Present price.
Adventure, copper, . .	Pittsburg, Pa.,	Michigan,	10,000		
Arizona Land & Mining Co.	Providence,	Arigona,	....	....	$10 00
Aztec, copper, ...	" "	"	20,000		
American, coal, ...	New York,	Maryland,	60,000	$25 00	
Beaver Meadows Coal & R.R. Co.	" "	Penn.,	....	50 00	
Bohemian, copper, ...	Philadelphia,	Michigan,	20,000	....	2 37
Buck Mountain, coal, ...	"	Penn.,	....	50 00	
Central, copper, ...	Pittsburg, Pa.,	Michigan,	20,000	1 35	12 00
Copper Falls, ...	Boston,	"	20,000	20 00	
Cumberland, coal, ...	New York,	Maryland,	50,000	50 00	14 00
Dauphin Coal & R. R. Co., .	Philadelphia,	Penn.,	....	50 00	13 00
Delaware and Hudson, coal, .	New York,	"			
Eureka, copper, ...	" "	Tenn.,	10,000	50 00	
Evergreen Bluff Co., . .		Michigan,	20,000		
Flint Steel River, ...	New York,	"	20,000	4 00	3 00
Fulton, copper, ...	" "	"	20,000		
Forest Improvement Co., . .	Philadelphia,	Penn.,			
Fond du Lac Mining Co., .	Superior, Wis.,	Wis.,	50,000		
Franklin, copper, ...	Boston,	Michigan,	....	4 50	
Gogebic, copper, ...		"	20,000		
Gold Hill Co., ...	New York,	N. C.,			
Hiwassee, copper, ...	" "	Tenn.,			
Huron, copper, ...	Boston,	Michigan,	20,000	4 50	3 00
Hazelton Coal Co., ...	Philadelphia,	Penn.,			
Irwin, coal, ...	New York,	"			
Isle Royal, copper,* . . .	Washington, D. C.,	Michigan,	20,000	11 10	8 00
Lehigh Coal & Nav. Co., . .	Philadelphia,	Penn.,	....	50 00	
Locust Mountain, ...	"	"			
Lykens Valley, coal, . . .	New York,	"	....	50 00	
Lykens Valley R. R. & Coal Co.,	" "	"	....	20 00	
Mass. Mining Co., copper, . .	Pittsburg,	Michigan,	20,000		
Minesota, copper, ...	New York,	"	20,000	3 50	63 00
Merryweather, copper, . .		"	20,000		
Metropolitan, ...		"	20,000		
National, copper, ...	Pittsburg,	"	10,000	11 00	85 00
New Jersey, zinc, ...	New York,	N. Jersey,	....	12 50	
North American, copper, . .	Pittsburg,	Michigan,	10,000	30 00	10 00
New Jersey, Franklinite, .	New York,	N. Jersey,			
Norwich, copper, ...	" "	"	20,000	11 00	1 00
North West, copper, . . .	Philadelphia,	Michigan,	10,000	19 83	
North Western, copper, . .	Pittsburg,	"	9,000		
Nebraska, copper, ...	Detroit,	"			
Pittsburg & Boston, copper, .	Pittsburg,	"	20,000	....	72 00
Phœnix Copper Co., . . .	Boston,	"	10,000		
Pennsylvania, coal, ...	New York,	Penn.,	50,000		
Pewabic, copper, ...	Boston,	Michigan,	....	3 75	50 00
Portage Mining Co., copper, .	Detroit,	"	20,000		
Quincy Mining Co., copper, .	"	"	8,000	9 00	
Ridge Mining Co., copper, .	Pittsburg,	"			
Rockland, copper, ...	New York,	"	20,000	2 00	30 00
Santa Rita, Silver Mining Co.	Cincinnati,	Arigona,	....	....	20 00
Sonora Exploring & Mining Co.	New York,	"	20,000	....	50 00
Sopori Mining Co., Silver,	Providence,	"	....	....	10 00
Southern Gold Co., . . .	Boston,	Georgia,			
Springfield, copper, ...	Baltimore,	Maryland,	100,000	5 00	
Superior, copper, ...	New York,	Michigan,	20,000	2 00	5 00
Toltec, ...	Boston,	"	20,000	15 00	2 25
Westmoreland, coal, . . .	Philadelphia,	Penn.,	40,000	12 50	

THE

MINING MAGAZINE

AND JOURNAL OF

GEOLOGY,

MINERALOGY, METALLURGY, CHEMISTRY, AND THE ARTS IN THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

DECEMBER, 1859.

ART. I.—THE LEAD DEPOSITS OF THE MISSISSIPPI VALLEY.— By PROF. J. D. WHITNEY.

[*Extracted from the Report on the Geological Survey of the State of Iowa. Vol.* I.]

THE great lead deposits of the Mississippi valley may be classed, according to their geographical position, under two heads: the Upper Mississippi and the Missouri mines; at the West they are commonly distinguished as the Upper and Lower mines. The first of these divisions embraces the lead-region lying in the south-western portion of Wisconsin, and including a small portion of each of the adjacent States of Illinois and Iowa: the second comprehends the mines in the State of Missouri, which lie chiefly to the south of the river of that name. These lead-producing districts possess many features in common, both in regard to the geological position and the mode of occurrence of the ore; but the Upper mines have always been, and will probably continue to be, much the most important.

It is with that portion of the Upper Mississippi mining region which lies within the limits of Iowa, that we have to do

in this Report; but, as a correct idea of the character of the lead-deposits could hardly have been acquired, had the examination been confined to that narrow space, it will be necessary, for the purposes of comparison, to take into consideration and develop in as brief a manner as possible, the principal features of the occurrence of the lead ores, as deduced from repeated examinations of different portions of the lead-region within the boundaries of each of the three States in which it is included. It is only after a comparison of the phenomena exhibited by the deposits of metalliferous ores in many different regions, that general opinions can be formed with any reliability as to the value of particular localities; and even then, after the most careful investigation of vein-phenomena in all their forms, the difficulty of the subject becomes apparent in the impossibility of deciding some of the most important questions in regard to them. Those who have not been made familiar with the appearances presented by metalliferous deposits, in many different geological positions, and under a great variety of circumstances, are very likely to be led to form erroneous opinions in judging of matters in which there is so little seeming regularity, and in regard to which the almost invariable tendency of the human mind seems to be to exaggerate.

The existence of lead deposits in the North-west was undoubtedly well known to the aboriginal inhabitants; but whether they were worked and the ore smelted into metallic lead previous to the time of the whites, is a question of some doubt. It is stated that, although galena has been repeatedly found in the mounds, no metallic lead has ever been discovered among the relics of the former occupants of the soil. It would seem, however, highly probable that the race which had skill and perseverance enough to mine the native copper of Lake Superior, in numerous localities, and, in some places, to a depth of fifty feet, in a rock much more difficult to work than the limestone accompanying the lead ore, would also have understood the simple process of smelting the lead from its pure and easily-reducible ore.

The first discovery of lead by the white race in this region dates back as far as 1700, when Le Sueur made his famous voyage up the Mississippi, as far as the St. Peters; up which stream, near the mouth of the Mukahto or Blue river, he supposed that he had discovered a mountain of copper ore. Al-

though this supposed discovery was a great mistake, yet there is reason to believe that he did find lead ore at different points along the Mississippi. About twenty years after this, mining was actually commenced in the Missouri lead-region ; although it was not until 1798 that it became a regular business, and was carried on with any system. It was nearly a century after Le Sueur's discoveries, before any attempt was made to open the lead mines of the Upper Mississippi. In 1788, however, Julien Dubuque, an Indian trader of French extraction, who had previously settled on the site of the flourishing city which is now called by his name, obtained a grant from the Councils of the Sacs and Foxes, which was afterwards confirmed by Carondelet, at that time Governor of Louisiana, of a large tract of land situated on the western bank of the river, including the rich mineral lands of that vicinity. Here he remained, engaged in mining and trading with the Indians, until his death, which took place in 1810.

It was not, however, until about the year 1822 that mining was regularly commenced in the Upper Mississippi valley. In that year, a number of individuals settled in the vicinity of Galena, and engaged in the business of digging for lead; and so rapidly did the excitement, consequent on the discovery of such rich deposits, spread, that by the year 1827, mines had been opened and worked over nearly the whole extent of the lead-region on the east side of the river. Up to the year 1830, the Indians had held possession of the west bank of the river, and had not permitted any encroachments of the miners on to their domain, which had not yet been ceded to the United States: in that year, however, in consequence of the hostility of the Sioux, the Foxes abandoned the vicinity of the river, and thus that region was opened to the whites, who immediately crossed over and commenced exploring and mining. They were soon driven away by the United States troops, as the land had not yet been purchased of the Indians. A small military force was stationed here, and under this protection the Indians returned and began to work at the localities abandoned by the whites, but probably under their direction, and chiefly for the benefit of the traders stationed on the other side of the river. After the close of the Black-hawk war, in 1832, which resulted in the ceding to the United States of a large tract of land, including the eastern portion of Iowa, a considerable number of miners crossed over and re-

sumed operations on that side. They were again driven off by the Government troops, as the treaty had not yet been ratified by the Senate. Finally, in 1833, permission was given to take possession of the much-coveted region. Attempts were made by the government to collect rent for the mineral lands, which, by the act of Congress of March 3d, 1807, had been reserved from sale. The system of leasing the reserved mineral tracts was kept up for a few years, with great expense and trouble to the government, and finally abandoned in 1847, when lands supposed to contain valuable ores and previously reserved on that account, were thrown open for entry and purchase.

Previous to this abandonment of the system of leasing, a geological survey of the lead-region had been authorized by Congress in 1839, for the purpose of ascertaining the extent of the productive lead formation, with a view to the preparation of a place for the sale of the lands reserved as mineral. The conduct of the Survey was intrusted to Dr. D. D. Owen, by whom, with the aid of a hundred and thirty-nine assistants, it was accomplished in the autumn of the same year, and printed without the maps and illustrations in 1840, and afterwards reprinted with these, in 1844. During the prosecution of the State Geological Survey of Wisconsin, the lead-region has been made the subject of two Reports, which were published by the late Dr. Percival, the State Geologist, and which are chiefly devoted to the discussion of the subject of the occurrence of the lead ores, and the stratigraphical geology of the region in which they occur.

The productive lead-region of the Upper Mississippi occupies the larger portion of the territory south of the Wisconsin river, between the east branch of the Peccatonica river, on the east, and the Mississippi on the west, and extends south into Illinois as far as Apple river. The Mississippi runs near the western edge of the mineral district; but there is a considerable area of productive territory on the west side of that river; the limit beyond which no ore has been worked on that side being the outcrop of the Niagara, as seen in the Geological Map accompanying this Report.

Nearly the whole of the area thus bounded, and which is peculiarly the lead-producing region of the North-west, is underlaid by the Galena limestone, of whose lithological character and distribution on the surface, within the limits of

Iowa, enough has been said in the preceding pages of this Report. Although this limestone occupies most of the elevated prairie region of the lead district, the larger seams are found almost universally to have cut down to lower groups; while undulations of the sandstones bring up these, so that they occupy sometimes a considerable extent of surface, where, if the dip were uniformly regular throughout the region, we should expect to find the Galena limestone occurring. The whole thickness of the series, from the top of the Lower sandstone to the bottom of the Galena is only from four hundred to four hundred and twenty-five feet, so that slight undulations of the strata, in a region irregularly denuded and furrowed deeply by the river-channels, will naturally give rise to considerable irregularity in the distribution of the groups upon the surface. The general southern dip of the strata, by which we are carried to lower rocks as we proceed northward, causes the Galena limestone to thin out gradually in that direction, and to be more and more restricted to the most elevated part of the region; so that, by the time that we have reached the water-shed between the streams flowing into the Wisconsin, and those running south into the Mississippi and its tributary Rock river, we find the Blue limestone occupying more space on the surface than the Galena; and we have to descend the valleys to the north but a short distance before we come upon the Upper sandstone.

The occurrence of lead ore in the region under consideration, is limited to the groups between the Hudson-river shales and the Lower sandstones; and it appears that no profitable workings have ever been carried on for any length of time, except in that part of the series which lies between the Upper sandstone and the Hudson-river group; while much the larger portion of the lead hitherto obtained has been raised from the Galena limestone proper. Within the limits of Iowa and Illinois the diggings are exclusively confined to this position, and, in Wisconsin, there are no productive workings in any other rock, except on the northern and eastern borders of the district. The distribution of the lead ore seems, in reference to its position in the geological series, to have been influenced by the geographical position and the development of different members of the series. Thus, where the Galena limestone has its maximum thickness, it will be found that the lead-deposits are limited to the central and lower portions of this rock, and by far the most abundant in the central,

never penetrating the Blue limestone. For instance, in the region between the Mississippi and Fever rivers and its immediate vicinity, which has always been the most productive part of the lead-region, in proportion to its superficial extent, and where the Galena limestone is developed to its full thickness of two hundred to two hundred and fifty feet, we know of no lead-bearing crevices extending down as low as the Blue limestone; and we have become satisfied that, in the great majority of cases, at least, the deposits have diminished in productiveness rapidly, after passing below a limit perhaps fifty feet above the base of the Galena. Neither have we ever known of profitable mining in the Upper portion of this rock: the first fifty feet seem to be almost as barren of ore as the Niagara limestone itself. If, however, we go from the district specified above, we find the thickness of the Galena limestone diminished, partly by denudation and partly by the original thinning out in that direction; and at the same time we notice the fact, that the lead deposits are found in lower and lower positions in reference to the geological horizon, until, at last, we reach the bottom of the Blue limestone. Here, however, the Upper sandstone entirely cuts off the ore, there never having been a single instance, so far as we can ascertain, of a crevice having been worked in that rock. Below this sandstone, in the Lower magnesian limestone, the rock becomes metalliferous again, but in a highly diminished degree; and it is not possible to include this formation in the productive lead-bearing series, as will be more fully set forth, farther on in this chapter.

The sulphuret of lead, or galena, is almost the only ore of that metal which is found in the Upper Mississippi mines; the oxidized combinations being exceedingly rare, and not of the slightest importance in an economical point of view. The carbonate of lead has been observed at the Blue-mound diggings, in reniform and stalactitic masses of considerable size: it is also said to have been found, in connection with the sulphate, at Mineral Point; but, so far as we know, no traces of arseniates, phosphates or any other of the numerous oxidized combinations of lead, have ever been observed in this region. Within the limits of Iowa, we have never noticed any other form of ore than the sulphuret, with occasionally a thin incrustation of the carbonate over it.

The chemical composition of the pure sulphuret of lead is:

Lead	86.6
Sulphur	13.4
	100.00

The galena of the western mines contains only the most minute trace of silver, a metal which is almost invariably found associated with lead, and frequently in sufficient quantity to be separated with profit. This is usually the case, however, only in the ore obtained from the crystalline and metamorphic rocks: the unaltered sedimentary strata furnish a much less argentiferous ore. The quantity of silver in the galena of the Upper Mississippi mines is by far too small to be worth separating; the smallest amount which can be profitably separated, under the most favorable circumstances, being from six to eight ounces per ton of lead, while the western lead ores rarely contain more than a fraction of an ounce to the ton.

The crystalline forms in which the galena presents itself in the western mines, is almost exclusively the cube. Occasionally the angles of the cube are replaced by the planes of the octahedron; but the simple cubic form is infinitely more common than any other. The crystals are usually rough and irregular, as if somewhat corroded on their faces, and grouped together into a variety of irregular forms. Occasionally, single crystals are of very great size: one presented to the State Collection by A. Estey, Esq., of Galena, measured about seven inches along one of its edges, and weighed over sixty pounds.

Different names are given by the miners to the different forms of the galena, according to the form and size of the crystals and their arrangement into groups. The terms "dice-mineral," "cog-mineral," "sheet-mineral," "chunk-mineral," &c., explain themselves, the ore of lead being universally designated by them as "mineral."

The freedom of the galena from intermixture with other metalliferous ores throughout the Upper mines, and, more especially, in Iowa, is remarkable. Sulphuret of zinc is almost the only one which occurs in any quantity intimately associated with the galena, and the large majority of the diggings do not show even a trace of this. Hence, the great softness and purity of the metallic lead of this region, and the high price which it bears in comparison with most of the important metal.

Having, in the preceding pages, given a brief sketch of the geographical and geological position of the lead-region of the Upper Mississippi, and noticed the mineralogical associations of the ores, we come next to examine their *mode of occurrence;* by which term is meant, the relations of the metalliferous deposits to the rocks in which they are enclosed, as to their form, extent and origin; on the careful study and complete understanding of which conditions depends our knowledge of the value of all mining property; as, the more thorough our acquaintance with the peculiarities of any class of ore-deposits, the less will be the risk in opening and working them. And before proceeding to describe the mode of occurrence of the lead ores of the region in question, it will be advisable, in as brief a manner as possible, to give a general idea of the most important varieties of form in which the metalliferous ores occur, as well as to define some of the terms used in speaking of them.

The forms assumed by the deposits of the economically valuable ores are various and complex, and the limits between them are not always capable of being drawn with such sharpness as to admit of their being satisfactorily classified. For convenience of description, however, it has been found best to arrange all the metalliferous deposits under two heads: the *stratified* and the *unstratified.* The first of these classes comprehends such masses of ores as are included within rocks of sedimentary origin, and which are in every way identical in their epoch and mode of formation with the strata in which they occur: this class of deposits may be illustrated by reference to the beds of iron ore in the Coal measures, which were deposited in the regular order of succession of the members of that series, one bed differing from another only in the chemical composition of the material of which they are made up.

The unstratified deposits, on the other hand, which class includes most of the forms of occurrence in which the metals other than iron and manganese are found, present a series of phenomena of a complex character, the real nature of which cannot always be easily made out. In the most general way, they may be divided into *irregular* and *regular.* The irregular, unstratified deposits include: igneous eruptive masses of ore, as for instance, the iron mountains of Lake Superior and Missouri; stockwerk deposits, or bodies of rock impregnated over an irregular space with metalliferous particles; contact-

deposits, or accumulations of ore between the planes of contact of two different kinds of rock-masses. From this last class, we pass by gradual steps to that of the regular unstratified deposits, or mineral veins, the term by which this division may most properly be designated. A mineral vein may be defined as an aggregation of mineral matter, of indefinite length and depth, and comparatively small thickness, differing in character from, and posterior in formation to, the rocks in which it is enclosed. Veins may be divided into three classes, *segregated*, *gash*, and *true veins*. Segregated veins, which are peculiar to the altered crystalline stratified or metamorphic rocks, are usually parallel with the stratification and of limited depth. Gash veins may cross the strata at any angle; but are limited to one particular group of strata, and are peculiar to the unaltered sedimentary rocks. True veins are aggregations of mineral matter, accompanied by metalliferous ores, within a crevice or fissure which had its origin in some deep-seated cause, and which may be presumed to extend for an indefinite distance downwards.

True veins are almost universally admitted by geologists to have originated in "faults," or dislocations caused by great dynamical agencies connected with extensive movements of the earth's crust, and for this reason they are believed to extend indefinitely downwards; an assumption which is supported by facts, since no well-defined vein has ever been found entirely terminating in depth, at any point which has yet been reached by mining industry. Gash-veins, on the other hand, are supposed to have originated in fissures produced by shrinkage, or some other cause confined in its action to a certain set of beds, and not extending into strata of a different character from that in which they originated. The principal distinction between true and gash veins, is, that the former may be worked to an indefinite depth; while the latter, however rich they may be for a certain distance, are sure to give out, or be cut off, on passing into another set of beds of a character unsuited to their development; so that no one vein can be made the seat of permanent mining operations, requiring a large amount of costly machinery, as is the case with true veins, some of which extend for miles in length, and have been worked downwards for centuries, without a permanent diminution of their metalliferous contents. Among the most striking characteristics of true veins, besides their persistence in depth,

are: 1st. The presence of a peculiar gangue or vein-stone, which consists most frequently of quartz, calc. spar or heavy spar, forming the bulk of the vein, through which metalliferous portions of the ore are disseminated; 2d. A peculiar symmetrical arrangement of the contents of the vein, especially of the gangue, which is called the *comby structure* of the lode, lode being synonymous with vein: this consists in a disposition of the different mineral substances of which the vein is composed, in parallel layers on each of the walls, with their crystalline faces turned inwards towards the centre of the lode; so that, if the vein were divided longitudinally into two portions, each of these halves would correspond with the other in the nature and arrangement of the material of which it was composed: 3d. Well-defined walls, or sides of the vein, which are often grooved and polished as if motion, accompanied by immense pressure, had taken place along these surfaces, and which are usually separated from the mineral substances forming the vein-stone, by thin bands of clayey matter, called *selvages*, the clay itself being known as *flucan*.

True veins are usually observed to traverse the rocks without being influenced by their stratification, sometimes coinciding in direction with the strike of the enclosing beds, but more usually cutting them at a greater or less angle. On passing from one set of strata into another of a different nature, they often undergo changes in the character of the vein-stone and the accompanying ore, but the fissure remains, even if quite barren of ore; persistence in depth being the most marked feature of this class of deposits.

Having thus noticed the most important characteristics of the different classes of mineral deposits, we shall be able to proceed more intelligibly to a discussion of the varieties of forms under which the very remarkable deposits of lead ore in the Upper Mississippi valley present themselves. These deposits approach most nearly in character to what have been designated above as *gash-veins;* but they are, in some respects, peculiar in character, no mining-region exactly resembling this in the mode of occurrence of its ores ever having been observed by us in any part of the world, unless it be in the Missouri mines, in which the conditions of the Upper mines are closely imitated, although on a somewhat more limited scale.

To go into the details of the arrangement of the lead-

bearing crevices or veins, and to give all the minute particulars of the mode of occurrence of the ore in the great variety of localities which have been examined in the lead-region, will be impossible in this place, as a full treatment of the subject would require far more space than can be allotted to it in this Report. It must suffice, at the present time, to set forth the general results which have been obtained in a number of examinations of portions of the lead-region made since 1852, and, illustrating the subject by reference, particularly, to localities within the limits of Iowa, to make a practical description of these principles to a discussion of the probable future of the lead-mining interests of the North-west, and the best course to be followed in order to their most economical and satisfactory development.

The first thing which impresses the mining-engineer, who visits the Upper Mississippi region, having an acquaintance with the important mining districts in other parts of the world, is the fact, that the mines here have only been wrought to a very limited depth and then abandoned ; so that, throughout the whole lead-region, where he will see one excavation where persons are still at work, he will notice a hundred others, where nothing is doing, and most of which appear to have been abandoned forever. Again, he will observe that, instead of an extensive and costly *plant* (as the machinery and fixtures of a mine are called) and a large body of miners, there will be usually no more than two persons engaged on any one vein or crevice, and that their machinery will be limited to a windlass and a bucket. Moreover, he will visit many diggings where no ore is raising, before he comes upon one which is producing lead ; and this will, perhaps, astonish him by the extraordinary amount of ore which is presented to view within the excavations, and the facility with which it can be mined and brought to the surface. Some persons who have been accustomed to deep mining in Europe, have visited the North-west, and returned full of contempt for the system adopted, as if the shallowness of the mines were the fault of the miners, and not the necessary result of the mode of occurrence of the ore itself. To maintain that the deposits of ore in this region are continuous in depth, is to attempt to convict all the miners who have ever worked here of imbecility. Did the directors of the Cliff or Minnesota mines propose to suspend operations, when they had reached the point where costly machinery

was needed to drain their works? There are, undoubtedly, some instances in which valuable bodies of ore have been left going down, on account of water; but it was because the general experience of the region has fully impressed the miners with the belief, that, in the large majority of cases, the outlay required for the costly machinery by which deep mines are kept free from water, will not be reimbursed; as the distance to which the crevices can be followed and ore found in them is always limited, and does not generally extend far below the point at which the water becomes too abundant to be kept under by simple machinery. We have mentioned before, that no crevice has ever been traced into the Upper sandstone, at least for more than a very short distance, or found in the slightest degree productive in that rock. The extreme depth to which a mine might be wrought, under the most favorable circumstances, if we suppose the crevice to extend from the top of the Galena to the bottom of the Trenton limestone, would be about three hundred and twenty-five feet in that part of the district where the first-named rock has its full development. In point of fact, however, the actual extent of metalliferous ground is much less than this; since, where the crevices are developed in the upper and middle portion of the Galena, they do not extend down as far as the Trenton, the deepest workings never having penetrated more than two hundred feet below the surface, and the actual mining ground, in the very large majority of instances, being comprised within fifty feet of vertical height.

The lead-deposits of the North-west do not, therefore, present the most important feature of true veins—namely, persistency in depth; neither do they, on the other hand, exhibit the character and disposition of vein-stone, or of wall-rock, which have been noticed above as belonging to that class of deposits.

On attempting to classify the mineral deposits of the North-west, according to their predominating forms, we find that they may be conveniently arranged under three heads: Surface deposits, Vertical crevices, and Flat sheets. The surface deposits are not peculiar to this region, or to any particular class of ores; they depend for their existence on the destruction of previously formed accumulations of ore, by the denudation or gradual decomposition of the rocks in which they were contained, and the consequent liberation of the metal-

liferous portions, which may remain irregularly scattered through the superficial detritus near the place of their origin, or be carried by currents of water or other causes to a distance from their native bed. In the forms of the vertical crevice and the flat-sheet deposit, and their combinations with each other, we have the modes of occurrence of the lead ore which are peculiar to this region, and which will be explained as briefly as possible.

Surface Deposits.—The masses of ore which have been liberated by the decomposition of the rock near the surface, lie imbedded in the clayey loam which forms the bulk of the prairie soil, and are called by the miners "float-mineral." The amount of lead obtained from this kind of diggings is small; but the occurrence of float-mineral is of importance to the miner, as being his chief guide to the discovery of the ore in the crevices. The fragments have not usually been transported far from their original position; and the discovery of loose pieces in the soil is an almost certain indication of the proximity of a deposit of more or less value in the adjacent rock, and it is the only one which can be relied on by the "prospecter." (Searching for ore, or *shoding*, as it is termed by the Cornish miners, is called in the lead region *prospecting*,)

In prospecting, the crevices are usually discovered at their outcrop in the valleys, where the denudation of the surface has exposed a considerable thickness of rock in the sides of the bluffs. When thus found and traced as far as is necessary to ascertain the direction of the lode, shafts are sunk along its presumed course, through the superficial detritus into the rock, until the crevice is struck; or, if not hit upon exactly in the shaft, drifts are extended each way until it is discovered. When the rock is not well exposed in the river sections, the difficulty of ascertaining the position of the crevices is vastly increased; and there are extensive tracts in the mineral districts where no lead has been discovered, simply because the rock is so deeply covered with soil and detritus, that explorations cannot be carried on without too great an expenditure of money.

Vertical Crevices.—The term *crevice*, as generally applied, in the lead-region, is nearly synonymous with vein or lode as used in other mining districts. It designates the

vein-like fissures, or gash-veins as they may be termed, in which the ore is found occurring, and especially those portions of them where the walls are near each other, and the fissure has not widened out into what is called an *opening*. A more general term still, for the accumulation of ore along a certain series of crevices and openings, is that of a *range*, and with this the word *lead* is nearly synonymous. To "strike a lead" is to come upon, or discover, a productive mineral deposit. The term "lead" may be a corruption of *lode*, by which miners usually designate a vein producing ore; or it may be a contraction of *leader*, a Cornish term for a branch of ore falling into the main lode, and thus *leading* the miner to its discovery. On account of the inconvenient similarity in spelling between the metal *lead* and the ore-bearing *lead*, the use of the latter should be dropped, and lode or range substituted for it.

The mineral-bearing crevices may be described individually, or in reference to their form, dimensions, the position of the ore in them, and other such conditions as appertain to each taken by itself: they may also be considered collectively, in their relations to each other, their grouping and general surface arrangement, as well as the imitations of their peculiar forms to the different subdivisions of the geological series.

(To be Continued.)

ART. II.—THE GEOLOGY AND MINERAL VEINS OF THE HILL OF CHAÑARCILLO, CHILE.—BY EDWARD B. DORSEY, Mining Engineer.

[*Communicated to Prof. Joseph Henry, Secretary of the Smithsonian Institution, and obtained from him for publication*].

DURING a visit to the United States recently, I was much astonished to find such imperfect knowledge of the mineral region of Chile, particularly when so many were anxious for accurate information of what may be called the first copper, and the third silver producing country of the world. To supply this, as far as in my power, and to make it available for all, I decided to make, whenever time and occasion would admit, geological sections of the principal mineral districts, based upon accurate measurements, and to send them, with the cor-

responding specimens of strata, to the Smithsonian Institution, where they would be in the reach of all who might desire information.

I have only had opportunity and time to make a section of the hill of Chañarcillo. Before describing this, it will be necessary to give a general idea of the geology of Chile.

Chile has two principal mountain ranges, running nearly parallel north and south. The first, or coast range, is distant from the coast about 40 miles; it attains its greatest height between 32° and 34° south latitude; in the south it is lost in the plains of Valdivia, while to the north of Coquimbo it is only found in low detached spurs. The second is the main cordillera, distant from the former about 60 miles in the north, widening to the south.

Between the two ranges there are many spurs running in every direction, enclosing numerous undulating plains, the largest being that between Copiapó and Huasco, about 100 miles long and 30 wide.

Both of the mountain ranges have the same general character, and are composed of the same ingredients, being principally quartz, orthoclose, albite, hornblende, and mica. As their proportions vary, are formed granite, syenite, trap, diorite, &c., &c.,—the changes being often imperceptible. In all the plutonic rocks, there is a large preponderance of hornblende.

The two mountain ranges form three distinct geological groups, with a general direction north and south.

1st. Extending from the coast to the east base of the coast range: this is of the same formation as the mountain ranges, and like them, is entirely unstratified. 2d. Is from 20 to 40 miles wide, included in the basin formed by the east base of the coast range, and the west base of the Andes, overlying the granite and other plutonic rocks, that probably extend from one range to the other.

The original formation of this basin or plateau was probably shales, limestone, and argillaceous magnesian limestone, which, by contact with the adjoining and underlying plutonic rocks, have been changed into metamorphic porphyries of every color, which generally retain the stratification of the original formation. Above this are found strata of dolomite and limestone, with more or less argillaceous matter, and irregular strata of porphyry, generally containing a small part of carbonate of lime.

The strata of this group are very much disturbed by the frequent irruption through them of igneous and plutonic rocks. 3d. The Tertiary and alluvium deposits formed subsequent to the upheaval of the mountain ranges, that are found overlying part of the granitic rocks near the coast, as well as part of the stratified formation of groups 2. Many shells of species that are now living in the ocean, are found buried in the sand, in some instances five hundred feet above the present level of the ocean, still preserving their original composition and form.

There are many theories as to the relative age of the two mountain ranges, but, until this difficult field is studied much more thoroughly than it has been, it will remain in doubt.

Gold and copper are found in the plutonic rocks of group 1.

Silver and argentiferous copper in the limestone, and porphyries of group 2. Silver generally predominating in the limestone, and copper in the porphyry.

The ores of lead and zinc, particularly galena and blende, are frequently found, but are very poor in silver, often containing not more than a trace.

There has been no profitable deposit of silver found at less elevation than two thousand feet above the sea, as the Ladrillo mines; or greater than nine thousand, as the mine, "Mina vieja de Cerro Blanco."

These remarks apply only to the part of Chile to the north of the Huasco river, where I have had frequent opportunities of making personal observations.

M. Domeyko* has made the most thorough, and, I think, the most correct geological examination of this country: the preceding differs but little from his opinion, from which it is mostly taken.

The part of Chile situated to the north of the 32d parallel south lat., is entirely devoid of vegetation, except the little that is on the border of the few small streams that rise in the Cordillera, and are soon evaporated or absorbed by the thirsty earth, long before they reach the ocean—unless a few stinted shrubs that are found in the valleys, or the bulbous roots of the plants, that are buried deep in the earth, can be called vegetation.

* Ann. des Mines (4) ix. 22.

About once in five years there is sufficient rain to moisten the earth about these roots, which in a short time clothe the sandy plains and rocky hills with most luxuriant vegetation, nearly every plant of which is covered with flowers, many being extremely beautiful ; this pleasant transformation has a very short life ; the summer sun soon dries the earth, the plants wither, when the hills resume their former arid and desolate appearance.

Water can generally be found at moderate depths in the valleys, though it is generally mineral or salt ; good water is very scarce.

Scarcity of good water and fuel, the high price of labor, and the expense of transportation in the desert region, are the great drawbacks to the development of the mineral wealth of this country.

As a general rule it will not pay to work copper ores of less than 20.00, and silver of less than .003 per cent., except under unusually favorable circumstances.

The principal silver districts of Chile, are Chañarcillo, Agua Amarga, and Tres Puntas ; all are situated in the limestone formation of group 2.

Chañarcillo has been, as it is still, the most important and richest. It is situated about fifty miles from the ocean, forming the south west extremity or terminus of a spur of hills, that runs from the coast range in a S. W. direction, having on each side wide valleys, which bear unmistakable evidence of having been large water courses at no remote period, though they are now dry. The valleys unite 2½ miles to the south of the hill of Chañarcillo, forming the northern end of the plain that extends south to the river of Huasco.

The summit of the hill (Candelaria Mine) is 1000 feet above the level of the valleys, and 3952 feet above the sea. The spur or ridge of which this hill is the terminus, gradually rises in height until it attains its maximum of 5600 feet above the sea, at a distance of twelve miles from this place.

As will be seen by the sections and specimens, this hill, as far as explored, is composed of nine primary strata, each of which is subdivided into many secondary ones, with an average dip of 11 per cent., from the N. E. to S. W., which is also the direction of the veins. The section is made from data taken from the workings on the principal vein, and the only true or fissure vein in the hill.

SECTION OF THE HILL OF CHAÑARCILLO.

The strata occur in the following order, commencing at the surface :—

A. Limestone, very broken, with many crevices that are filled with crystals of carbonate of lime, and a chalky argillaceous earth : the veins in this have not been productive ; average thickness, 90 feet.

B. Metalliferous brecciated strata of limestone, cemented together by carbonate of lime, crystallized, or in loose powder united with argillaceous matter. This heaves or displaces the veins horizontally about fifty feet to the west—that is, the part of the vein that is below the strata, is that distance to the west of the superior part. This has the character of the stockwerk deposits of the Germans, being crossed by numerous small veins in every direction ; the majority and richest, however, have a N. E. and S. W. direction. The ore from this stratum, after being assorted by hand, seldom yields above .0015 per cent. of silver. Thickness, 40 feet.

C. Blue limestone—dolomite. This is the most productive stratum of Chañarcillo, having produced .75 per cent. of the gross product. Some of the secondary strata of this are much more productive than others, for which no rule can be established. Thickness, 500 feet.

D. Porphyry,	Average thickness	230 feet.
E. Limestone,	" "	100 "
F. Porphyry,	" "	490 "
H. Limestone,	" "	90 "
H. Porphyry,	" "	100 "
I. Limestone,	Thickness thus far,	110 "

The deepest working in the hill is at present in this stratum, the vein yielding very rich ore.

The principal vein has been productive in all the limestone strata, though the yield has decreased as the depth increased.

The strata called limestone are composed of carbonate of lime, carbonate of magnesia, and argillaceous matter in very variable proportions, forming generally an argillaceous dolomite. The part of the hill in which productive mines are situated is about six thousand feet in length and five thousand in width; many mines are worked out of this limit but have not been productive.

The numerous veins of the hill can be divided into two classes. The first and oldest are the metalliferous veins, in which the gangue is mostly calc-spar and per oxide of iron: they run N. E. and S. W.; only one of these is a true fissure vein; it runs N. 25° E., with an average underlay of 15 per cent. west, and width of three feet, though it is sometimes fifteen feet wide in good ore. It is composed of three distinct branches, separated a few feet, rarely united; one of the branches has a gangue composed almost entirely of calcareous matter, while the others have, in addition, a large quantity of clay and per oxide of iron.

This vein has been worked to a depth of sixteen hundred feet, and over two miles in length; it is not affected in passing through the porphyry.

The balance of the veins of this class belong to the segregated order, varying in width from two inches to two feet, and underlay of 10 to 30 per cent. to the west. None of these can be traced in passing through the porphyry strata; some apparently do not extend below, while others are found with the same characteristics that they had in the superior strata of limestone, although their yield has been very little in the lower limestone strata.

The second class are those that run at various angles with the above, generally containing little or no calc-spar; they are of a posterior formation to the first class, but anterior to that of the faults, to which many of them bear strong resemblance. They are only rich or metalliferous at their intersection with the veins of the first class. The faults run from S. E. E. to N. W. W.; they have nearly the same composition as the strata through which they pass, though much more brecciated or earthy in their formation, caused evidently by attrition.

Going from the south to the north, the faults have heaved the veins to the west, (which it will be recollected is the direction of the underlay of the veins,) without regard to the angle, whether obtuse or acute; the same fault may heave one

vein on the side of the obtuse angle ; while another, running in a different direction, will be heaved on the side of the acute angle, the movement in both cases being in the same direction.

The fault K at the base of the hill heaved the vein fifty feet ; and Q, at the summit, three hundred and sixty-eight feet—in both instances, to the west. The intermediate faults caused only a local change in the direction, or, in other words, bent them, having the same effect horizontally as vertically ; the latter can be seen at a glance by inspection of the section ; there has been no movement outside of the faults L and P.

The veins beyond or outside of the faults K and Q have been unproductive. However, those beyond the former have been very imperfectly explored.

The most usual ores of silver found above the first porphyry strata are, bromide of silver, chloride of silver, chloro-bromide of silver, and native silver ; below it, the simple and compound sulphurets, arsenical silver, and native silver. Iodide of silver has been found in small quantities.

In the superior strata, the gangue is generally crystallized and massive carbonate of lime and per oxide of iron, forming a calcareous-ferruginous mass, in which the ore is found in laminæ, crystals, or disseminated through the mass. In the inferior strata, the per oxide of iron is generally replaced by the sulphuret of iron and arsenic.

Galena and blende are rare, and generally poor, even when found in contact with rich ore.

Quartz and sulphate of barytes are also rare and seldom found with silver ; they are regarded as unfavorable signs.

Native amalgam has been rarely found, and no gold or copper.

The quality and quantity of the silver ore varies very much, in some cases yielding 90 per cent. of pure silver, while the present average is not above 1 per cent. Ten years ago, a mass of chloro-bromide of silver and native silver was found near the summit of the hill (at the depth of one hundred feet) that weighed about 45,000 lbs., yielding 75 per cent. of pure silver.

The mines are perfectly dry; occasionally a small stream is found leading from cavities or other deposits of water, which ceases as soon as they become drained.

No organic remains have been found here, that I am aware of, except three ammonites, two of which I found my-

self; both were imbedded in the solid limestone rock.* One was found, two feet from the vein, at the depth of four hundred and ninety feet below the surface, and forty feet above the first porphyry strata. The other was found two and a half feet from the vein, one hundred and ten feet below the surface, and eighty feet above the porphyry.

The formation is of the oolitic age, although it is very difficult to say with certainty, on account of the almost total absence of fossils.

The silver has been deposited, or at least a part of it, in the veins at a comparatively recent date, subsequent to the origin of the slides and faults, they being frequently impregnated with silver. Moreover, chloride of silver, bromide of silver, chloro-bromide of silver, and native silver, are very often found encrusting and being encrusted by crystals of carbonate of lime, bearing unmistakable evidence of having been produced by causes that are still in operation.

Chañarcillo was discovered in 1832; since then about three hundred mines have been worked, producing a total of sixty millions of dollars ($60,000,000), nineteen-twentieths of which have been produced by twenty-five mines. At the present time, seventy-eight mines are worked, employing twelve hundred men, producing monthly twelve thousand quintals (1,200,000 lbs.), or eight thousand pounds of pure silver.

The yield has decreased very much lately, and will probably decrease much more, as there remains but little ground to explore in the upper limestone strata, where the segregated veins have been the most productive—in fact, many that have been very rich in this stratum, have been entirely unproductive in the lower strata.

The mines in Chile are generally very badly worked, having the old Spanish system of inclined passages, instead of perpendicular shafts. Many mines are worked on a large scale at a depth of over two hundred yards (vertical), and have no other way of getting the ore out, except in leather bags, on the backs of men, through these inclined passages.

One man can make twelve trips daily from a depth of two hundred yards, with one hundred and fifty pounds on his back; for which he will be paid about thirty dollars a month and

* This was given to Lieut. J. M. Gillis, U. S. N., when last in Chile, October, 1857.

his food, which consists of two pounds of bread, and as many boiled beans as he can eat daily.

Such a large quantity of the rich ore in former times was stolen by the workmen, that the persons in charge of mines were obliged to establish the rule of searching every one coming out of the mine. For this purpose, at the mouth of every mine there is a room in which all leaving the mine are obliged to strip entirely naked, and change their cloths. Notwithstanding this strict search, they manage to steal frequently by hiding the ore in their mouths or other places.

Within the last two years, the mine-owners have seen the necessity of working the mines with more system, as the expense of working a deep mine with the old system is ruinous, without considering the delay and inconvenience: for this purpose, they have employed capable mining engineers, who have introduced some system into what before was nothing but confusion.

My experience in the hill of Chañarcillo enables me to make the following general deductions; which, however, are only *applicable to this particular district:*

The same stratum has the same effect on different veins—that is, if one vein is rich, there is a great probability of others being so, passing the same stratum.

The same cross-vein has different effects upon different veins.

After passing a certain nominal depth, the veins become less productive in proportion as the depth increases.

The productive veins run from S. W. to N. E., with underlay to the west.

The veins have been generally richer near the faults.

The veins have never yielded any silver in the porphyry strata.

It was my intention to send with this the statistics of the production of metals in Chile; which, on account of the present revolution, I have not been able to obtain.

CHAÑARCILLO, CHILE, Feb. 1, 1859.

Art. III.—PETROLOGY AND METAMORPHISM.*—By Oscar M. Lieber, State Geol. of S. Carolina.

1. *Elements of Chemical and Physical Geology.* By Gustav Bischof, Ph. D. Cavendish Edition. By Paul & Drummond. London 1854.
2. *Lehrbuch der Geognosie.* Von Dr. Carl Friedrich Naumann. 2d Edition. Leipzig 1858, vol. I.

Many of the natural sciences, which were formerly studied as mere matters of description, are now viewed in a more philosophical light. The alphabet has given place to the grammar. The dreary catalogues of hard names are abandoned for the investigation of principles, laws, and relative effects. Comparative anatomy, zoology, palæontology, botany, are no longer content with the stagnant rehearsal of difficult terms, or the memorizing of barren descriptions; but aspire to the far more important consideration of general order of plan, conception, and reciprocal influences. A similar improvement may be seen in the science of petrology. It is true that this change does not date altogether from yesterday. The whole of this century, and even the latter years of the past, were, in part at least, occupied by endeavoring to determine the facts relative to the genesis of rocks. The great Werner led the way, and thus eliminated, as it were, the new science of geognosy. But he, as well as his successors, whether followers or opponents, were necessarily premature theorists. Other sciences were first to develop, before a true knowledge of the crust of our globe, based upon their correct application, could be established—and thus, even now, the accumulated facts of three-quarters of a century show us that we have progressed no farther than into the vestibule of our science. Yet, little as this may appear, we have already gained much. We are aware of our position. We know the direction in which the advance is to be made. *We have at last been taught that the great battles of Geology must be fought within the fields of chemistry and natural philosophy.*

We may, at the present time, discern two strongly individ-

* The following pages were written as an introductory chapter to my 4th Rept. on the Survey of South Carolina, not yet published. The references to other Reports designate those already published. O. M. L.

ualized parties engaged in the investigation of the formation of the different components of the crust of our globe: the one is composed of purely observing geologists, the other of pure chemists. The first endeavors to determine all matters in geology by the mere use of the eye; the other applies to the laboratory in all cases, and is prone to generalize from small experiments. As in all similar instances, it is no doubt the case here likewise, that both carry their point too far; although there can scarcely be a doubt, either, that, in the present state of the science, the latter are more likely to produce important results.

Metamorphic action, and the genesis of crystalline rocks, especially of those to which a plutonic origin has been ascribed—these are the great questions, which have of late elicited most debate.

Metamorphism, in the widest application of the term, would embrace every change, every transformation, to which rocks, or their constituent materials, are subjected. It would comprehend all the alterations which Naumann* describes under the general term of *alloösology*.† Nor have we indeed really sufficient reasons for distinguishing in this respect the chemical changes produced with or without the co-operation of atmospheric influences; for, in reality, as far as the immediate *chemical action* is concerned, there is probably but little difference between the process discernible in the production of the crystalline mass of a solid rock, and that of the various results of their decomposing exterior. Yet we are accustomed to designate by the word "metamorphism" that particular action, which occasioned the production of the ancient crystalline rocks, especially the slates:—micaceous, talcose, hornblendic, and others. Naumann terms these schistose rocks "cryptogene," with a view to designate our ignorance of the precise cause and method of their production; but the introduction of a new word, where nothing is to be gained, and especially of a provisional term, to be discarded when our knowledge has increased, appears to me only to open the door to a quibbling verbosity, without any corresponding advantage being gained. Employing, therefore, as heretofore, the term "metamorphism" in its accepted specific

* Lehrbuch der Geognosie.

† From ἀλλοίωσις, change, since metamorphism is already in use in another and special application.

meaning, we may venture upon a passing examination of the abandoned and existing views concerning it. Hutton and Playfair were the first to assert that the schistose, crystalline silicate rocks (the micaceous, talcose, and slates), were the results of alterations effected upon deposits of sand or clay, of different degrees of purity. Boué attached himself to this doctrine ; and latterly, Sir Charles Lyell, and Studer, have become most prominently conspicuous as its advocates—the last having, however, adopted the view that the change was not produced, as the others had suggested, by the action of internal heat, but rather by a peculiar molecular activity in the mass itself. Von Morlot, whose views coincide with those of Studer, has termed this suggested mode of alteration "*latent* metamorphism," to distinguish it from *contact* metamorphism. Volger has carried the theory of metamorphism farther than any of those just mentioned, by asserting the possibility of the formation of pyroxenic or amphibolic rocks, quartzites, felspathic rocks, &c., from limestone.*

On the other hand, again, we have the views maintained by that school of which Bishof is a leading member,—views, according to which the changes, which these rocks must have undergone, are easily, and indeed *only*, explained by aqueous chemical process. This theory has been carried out, with great ardor, in reference also to the origin of those rocks to which geologists have long been in the habit of ascribing a pyrogene (or igneous) origin. By a gradual process of decomposition, reduction, oxidation, and recombination, under the influence at times of permeating solutions of other substances, all metamorphic changes are regarded by Bishof, as having taken place at temperatures not widely differing from those of our atmosphere. Progressing in the same direction of inquiry, he combats those theories which would ascribe a pyrogene origin to the rocks, which geologists had considered as plutonic, *i. e.*, sub-aqueous igneous rocks of an earlier period. The presence in the plutonic rocks, as well as in the metamorphic slates, of minerals whose composition would prevent their unaltered existence at a higher temperature, induced Bishof to discard the theory of igneous agency in the formation of either. It is clear, however, that great distinction should be drawn between the two very different questions :

* Lehrbuch der Geognosie, Naumann, p. 720.

the first of which relates to the ORIGIN OF THE MASS, the second to the CONVERSION OF THE MATERIAL INTO ITS PRESENT SHAPE. The former is a *physico*-geological question, the latter a *chemico*-geological one.

Giving all credit to the laborious and valuable researches of Bishof and his close followers, and freely acknowledging that they have contributed more than any others to the development of that branch of the science here concerned, it is impossible to close our eyes to the fact, that a great deal of avoidable scientific disputation and recrimination has been engendered by momentarily forgetting the total difference of these two questions. The purely observing geologist has thus sought to explain the formation of the existing mineral combinations in the unstratified crystalline rocks by the undivided agency of heat; while he, who represents the purely *chemical* school, ascribes the origin of the mass to aqueous sedimentary, or aqueous chemical, action. The two proceed from immediately opposite starting-points: the one drawing conclusions as to the formation of the present compound from the source of their chief components, or the mode of introduction of the materials originally filling the space, which they now occupy—the other arguing as to the mode of introduction of the materials from the accepted view in regard to the formation of the present compounds. As an engineer would find it impossible to mine and counter-mine with satisfactory results, without having previously acquired a correct knowledge of the grounds to be operated upon, so we must here be prepared for incompatible differences of opinion, until first far more observations have been made and far more facts have accumulated.

There can be as little doubt that Bishof is incorrect in refusing to admit the possibility, under particular circumstances, of the ex-crystallization from a fused *magma** of minerals containing water or carbon, as there is, that those are mistaken, who entirely discredit the possibility of certain changes being admissible in solid rocks.

Bishof thus appears unwilling to allow geologists to apply the terms *igneous*, *eruptive* or *pyrogene* to any rocks which are not clearly *volcanic*. He even would seem in doubt as to

* This term is constantly employed by continental European geologists to indicate such homogeneous semi-fluid masses of rock-producing material. It cannot be objectionable to introduce it into our language, for we need such a word.

whether these terms are applicable to all *lavas ;* for the existence of crystallized labrador in the ancient lavas of the Auvergne, of augite in the lava of Bansenburg, of leucite in that of Vesuvius, and others, are adduced as evidence that these rocks, as such, could not have been formed from a fused mass. Where men, so much more capable of settling the points at issue, are still disagreed, I shall not attempt to answer the questions as to whether or not exposure to the absorption of water and oxygen during a very slow process of cooling might not sufficiently account for the presence of these minerals and their formation in a still partially fused *magma ;** but merely mention it to show that two entirely different things are referred to, when we speak of the igneous rocks of the chemists on the one hand, and of the igneous rocks of the geologists on the other.

"Now, since rocks, which are unquestionably of volcanic origin," says Bishof,† "either do not contain any, or only very small, crystalline minerals; since this is the case even in the largest masses of lava, that may have been years or even centuries in cooling, the inference that crystals of quartz and felspar, a foot in length, have been formed by fusion, and that rocks, such, for instance, as the granite of the Riesengebirge, in the druses of which such crystals occur, were formerly melted masses, is inconsistent both with facts and with the analogy which is assumed to exist between such rocks and lava. Inferences from premises that are not proved, but rest merely on assumed analogies, must be erroneous when they are inconsistent with these analogies."

The great champion of the extreme chemical school here throws down the gauntlet to all who are unwilling to dispense with autoptical observation of nature; and thus, even here, it may not be improper to hazard a few conflicting remarks.

Even if we were to concede the point as to the ex-crystallization of minerals in a solidified mass, Bishof's argument could not gain very much by it; for immediately preceding the above quotation, he says: "It is evident that, after the

* On pages 94 and 95, Vol. II. of the Cavendish editions of Bishof's *Elements of Chemical and Physical Geology*, this matter is discussed. Bishof considers these crystals to have formed subsequently in the hardened mass—a view scarcely to be credited when we perceive the beautifully perfect developments of such finely formed crystals as those of leucite. How could perfect crystals form without space and with constant and unequal resistance on all sides?

† Bishof, as above, p. 95.

solidification and cooling of lava, crystals can no longer be formed by fusion. Therefore, when we find that the older lava contains crystals which do not occur at all in the more recent lava, or which are at least much larger and better developed than in the latter; it is certain that these crystals have been formed in some other way than by fusion, and there is no other than the wet way in which they can have been formed."

In the very first instance, there seems to be quite a considerable difference between the assertions that crystals are formed by *fusion*, and that they are produced by *cooling*. To make it appear that those who believe in the existence of plutonic rocks regard such crystals as formed by fusion, is therefore only to set up a man of straw for the purpose of bringing him to the ground. But this is probably an error of the translator, for which the author is not responsible. I think that Bishof, in his German work, has uniformly employed the term *pyrogene origin* to designate the method of formation, which had been ascribed to such rocks.

But to proceed—Bishof has himself shown the existence of these crystallized minerals in certain rocks, which are, as he himself admits, undeniably true lavas, and hence must be eo-ipso primarily of igneous origin. They occur especially in the most bulky and the oldest masses; in which, therefore, slow cooling might be reasonably conceived to have taken place. The larger and better development of such crystals in the older masses can scarcely be an evidence of their production by processes exclusively humid. Bishof would infer an imperceptibly gradual development of the crystals after complete solidification of the mass, though the evidence would seem here to be altogether the other way. The greater lapse of time which might have been accorded to the formation of crystals in the older lavas employed to explain their greater size, is scarcely needed to prove the entire production even of such crystals. Centuries, or even thousands of years, are surely not requisite for such a purpose; and the interruptions, which would be more likely to exist during so long a period than during a shorter one, would tend to increase the irregularities of the individual crystals. But we need not detain ourselves with this immediate subject. It is sufficient for us to perceive that such crystals may be formed in rocks, unquestionably pyrogene, and we can be guilty of no inconsistency if

we assert that many other rocks, whose mode of occurrence (in dykes, &c.,) suggests an eruptive origin, may really be pyrogene, notwithstanding that the individual mineral combinations within them, of which they are constituted, are incapable of resisting the influences of heat without entire change. Even admitting Bishof's doctrine of a sort of posthumous ex-crystallization in the solid mass without any modification of views, why should it be impossible for a granitic mass to be of igneous origin? Silicic acid is too powerful, we are told, to remain in close proximity to bases in a state of fusion without entering into combination with them; so that, instead of a granite, we should have a trachyte. But why not, then, according to Bishof's theory, might not all granite be the result of the subsequent crystallization of a trachyte, and yet the mass still be igneous in its origin? The presence of minerals, which cannot withstand fire or great heat, positively proves nothing as to primary origin; for even Bishof himself would not assert that the mineral substances which now compose the mass are the same that were originally introduced, and that it was by this particular humid action, which such minerals indicate, that the space, now occupied by them, was primarily filled. His argument can have reference only to the existing materials; and there is nothing in his position to satisfy us that this subsequent chemical modification might not, with equal efficiency, have converted a pyrogene material to the substance now visible, as it might have alone one of aqueous origin. The geologist can therefore perceive in Bishof's argument no reason why he should at once discard his belief in the primarily pyrogene origin of the mass.

However, we are not prepared to make this great concession as to subsequent ex-crystallization, except to a very limited extent, and under very peculiar modifying circumstances. The case of the quartz and felspar druses of the granite of the Riesengebirge, which Bishof cites, is such an exception, and a very conspicuous one. These are druses, he states, and there is probably now no geologist to be found who would ascribe to druses any other than an aqueous origin.

The formation of druses very closely coincides with that of infiltrative veins. Such veins, indeed, exhibit to our view the products of exclusively or inconspicuously modified aqueous action. In form they closely resemble the dykes of homogeneous rocks; yet who would mistake the one for the other?

Who would conceive their original formation to have been the same? The veins are distinguished by a very large proportion of free silicic acid, and usually by a greater quantity of sulphurets than the dyke-rocks; still many of the same minerals are found in both. Yet, without reference to any chemical difference whatever, the fact is already all-important, that, with the rocks referred to, the entire mass is an homogeneous mixture of crystallized substances, disseminated with marked uniformity throughout; while in the veins we find these substances distributed in particular groups, now occupying their parallel position along the walls, now following certain peculiar directions within the wedge-shaped mass (as with lodes, courses of ore,) now filling certain cavities, or now again occupying distinctly individualized, though irregular, spaces. Such difference is too great to be overlooked; and if, in the one instance, (with veins,) we are convinced that the true origin is that of a chemical precipitation, we can scarcely permit ourselves to consider the material filling the crevices of dykes to have been produced in the same way.

Bishof, it is true, insists very energetically that metalliferous veins could not be produced by ascending solutions, as Elie de Beaumont first asserted, *because a solution cannot effect a deposit in its channel without evaporation or depression of temperature.* This would, no doubt, be true if such premises are assumed; but I confess it would be no easy matter for me to understand how a stream of water, escaping from regions of a high temperature, and passing up through a crevice in rocks, which must have been less highly heated the higher it rose, should not itself become gradually cooled down. Indeed, it cannot possibly have been otherwise. Assuming, then, such depression of temperature, the deposition is readily explained. As I have attempted to show in my last Report, there certainly are *exogene* veins. But it is as certain that those veins, which are persistent, must be of *endogene* origin, or numerous obstacles would have checked their perfect and continuous development. Most certainly with a spring, issuing forth like the water of an artesian well, the force exerted is far greater than it could be in a descending stream, where no pressure, but that of the immediate column, could be exerted. All the obstructions, which in the latter case would be particularly abundant, would therefore act much more injuriously than in the former, where the force of the stream would

either discharge them, or entirely prevent their accumulation.

We have not introduced into this discussion any argument referring to the form of the bodies, to the study of which our enquiries tend. This is, however, a very noticeable point, and while we freely admit the vast importance of chemical investigation in this department of geological study—while, indeed, we are ready to assert that such men as Bishof have done more, probably, than any others, to regenerate the science in this field of enquiry, we are forced to deplore the want of attention which the purely chemical school exhibits towards the mode of occurrence of a large portion of the rocks, to which a plutonic origin has been ascribed. I allude to those occurring in dykes, or in irregularly intrusive masses. This form distinguishes them at a glance from the stratified sedimentary rocks traversed. Some of these rocks, the *eurite* of Chester, York, and other districts in South Carolina, for instance, described in previous Reports,* and possibly the *epidosite* occurring in the same State, are very likely of segregative origin. The eurite, and more especially the coarser quartz, felspathic porphyry and the pegmatite, very frequently present sufficient analogies with veins, properly so called, to render this very probable. Still there are a variety of other rocks, which with us are represented by the porphyries and the fine grained aphanites and diorites—rocks which occur either in dykes or in shapeless intrusive masses, concerning which a similar origin could scarcely be conceived.

In connection with the morphological considerations of these bodies, some noticeable facts may be added well calculated to contribute light upon the subject of their origin. In my last Report, I requested the reader's attention to the fact that, on either side of the belt of the porphyroid and fine grained aphanites, diorites, &c.—in which the course of the dykes corresponds with the general direction of the entire zone —the dykes of the same rocks present a marked uniformity in their opposite strike. The main belt and its constituent dykes have a general north-eastern course, while the tributary dykes, equally, generally possess a north-westerly strike. This year has contributed some important additional facts in this respect. Thus, in North Carolina, where I was requested

* Reports on the Progress of the Survey of S. C., by the writer.

last spring to make some examinations in behalf of gentlemen interested in the Cheraw and Coalfield railroad, I observed that all the dykes traversing the sandstone of the coal region, north of Chesterfield and Marlboro' Districts, have a north-west strike. The dykes are of a very coarse aphanitic porphyry; they lie entirely east of the main belt. In Anderson District, I made another similar observation. All this speaks for an intrusive origin.

The irregularly shaped, but exceedingly interesting, body of felsitic and diritic porphyry around Calhoun's Mill, in Abbeville, contributes another interesting fact. The body is surrounded by a siliceous ridge, (partly hornstune, partly sandstone) the dip of whose beds, although not entirely *produced* by the intrusive porphyry, is very perceptibly *influenced* by it. Standing upon this ridge, we look down upon the comparatively level country of the porphyry (hence locally termed the Flat-Woods) as upon the bed of an ancient lake. I have elsewhere, especially in Chester District, noticed this singular feature, but never with equal distinctness. The very friable sandstone, of which a large portion of the ridge is composed, would entirely prevent us from supposing that disintegration, decomposition and abrasion had caused the surface of the porphyries to become depressed, while the surrounding rocks were left standing; so that there is really, it would seem, much reason to suppose that there was an original basin or valley (partly produced, it is true, or at least altered in shape, by the outpouring mass,) the more depressed portions of which were overflowed by the original fluid or semi-fluid eruptive magma.

In the preceding pages, we have devoted almost exclusive attention to the discussion of the views taken by those who have devoted their entire attention to chemistry, and who may thus not unfrequently have been led to disregard too much the different circumstances which we are not unauthorized to conceive as having existed during other periods of the formation of the globe. We may now append some remarks upon the theories of those who, confining themselves entirely to autopsy, undoubtedly in innumerable cases are led to erroneous assumptions. A prominent one of these infers that all eruptive rocks are necessarily at once formed in the manner in which they now present themselves. The possibility of those changes, which are admitted in the case of metamorphic sedimentary rocks, are not unfrequently denied to the former.

That certain changes do, in reality take place, even in

solidified rocks, cannot be questioned, although we may not venture to place entire confidence in the extreme views of Bishof. Of such alterations, we have indeed frequent evidence. Bishof, in his great work, cites an innumerable quantity, many of which are beyond all dispute. I have thus noticed vast bodies of limestone replaced by quartz rock (chert) in Northern Alabama, where the entire mass is almost constituted of Silurian fossils, (madrepores, fenistella, archimedes, &c.,) which were necessarily originally calcareous. This is a parallel instance to some which Bishof refers to. A similar case is seen in the silicification of eocene oyster beds at Fort Motte, in our own State. Silicified wood is a very well known instance of a similar nature. Again, there are cases where one and the same dyke presents a soapstone at one point, and a dioritic porphyry at another.

Certain changes thus undoubtedly have taken place,—changes affecting both eruptive and sedimentary masses. But such changes are not necessarily without limits; nor is it at all certain that they are constant and progressive in all cases, and uninfluenced by the great changes, which have taken place in the formation of our planet, and whose proof must be sought in very different fields of study from that of chemistry. The cases where alterations of this description take place *now*, especially those where crystalline masses are formed, must necessarily be few and partial; and it is very necessary at this period of the argument, to remind the reader of the fact—without farther attempting to investigate its cause—that we have before us no evidence of any crystallized sedimentary (metamorphic) rocks of recent geological age. Even as far back as the carboniferous era, such transformation is rare and partial; and, although we have no definite means at our command of determining the *geological age* of nonfossiliferous strata, yet all the evidence at our disposal ascribes a greater age to these metamorphic slates. Where they occur in bulk, they never appear to be newer than the Devonian at all events, and probably chiefly belong to the Silurian or even Cambrian system (the taconic system of Emmons). They all appertain to that which former geologists termed the transition—and in the superincumbent formations, nothing of the kind (except indeed as isolated mineral accumulations) has ever been discovered. Surely this is a fact which de-

mands the most cautious consideration, in investigating the physical and chemical history of the planet. Besides this, those of the extreme chemical school, appear too frequently to forget in their arguments (not in their experiments) the very important circumstance, that evidences of *humid chemical* action after solidification, are no evidences whatever of *humid mechanical, i. e. sedimentary* action. They have not necessarily any thing in common with one another.

Little as we have been able to discover concerning the subsequent changes, enough is already known in regard to them, to show us that the mere identification of the character of a particular rock is not necessarily, even from analogy, always sufficient to establish the origin of the mass. It is readily conceived, that there may be cases, where a strictly sedimentary mass can be so altered as to coincide with a material, which elsewhere represents an eruptive body, and vice versa. The hand specimen is not always capable of settling the point; and yet the most common error of the anti-chemical schools, is a forgetfulness of this fact.

The question as to the precise manner in which these great changes were produced, is a difficult one to determine—indeed in our day this is as yet altogether impossible. We know that these changes are chemical ones, often resulting from the introduction of a new substance, or the extraction and removal of one already present. But the individual cases must have required peculiar circumstances, which differed in almost every instance, and thus produced the great varieties of rocks, and the gradual passages of one into the other.

The alterations being strict humid chemical ones, and such chemical activity being materially assisted by the co-operation of heat, we are not only permitted, but obliged to infer, that this particular chemical action was also greatly aided by a high temperature. That the sedimentary rocks, thus transformed, were exposed to an increased temperature at a period subsequent to their deposition, and without the necessity of presupposing any specific local igneous action, cannot be doubted.

Such a marked increase of temperature in the same mass, would necessarily be produced by the gradual elevation of the isothermal planes, consequent upon the subsequent deposition of superimposed rock-strata. "Babbage first called attention

to the fact, that the *chthonisothermal* * planes of the crust of our globe must be dependent upon the variable character of the surface, and that when seas or lakes in the course of time are filled up by sedimentary strata, a gradually progressing elevation into a higher level, must of necessity take place with regard to the isothermal planes. The same idea has been developed by Herschel, Lyell, and Virlet, and has by them been employed to explain the cryptogene (metamorphic) rocks. . . . The gradual filling up of an oceanic basin, ten thousand feet deep, would elevate the temperature of its original bed 100° centigrade (180° Fah.). . . . . In the same manner as this fact would be capable of converting bituminous coal seams into anthracitic ones, so also would clay slate, sandstone, and limestone, be subjected to more or less important transformations, and if any idea is capable of supporting the view that the cryptogene rocks are simply metamorphosed sedimentary beds—the knowledge of an increasing temperature produced by the thickening of overlying deposits, is certainly the most potent. It is readily understood also, that such transformations would belong to normal metamorphism, as they would influence the beds throughout their entire extent."

In presenting this statement, I have again given the words of Naumann,† as it would have been impossible to offer it more briefly and clearly.

As closely bearing upon these observations, I would beg leave to remind the reader of Daubrée's remarks, quoted in the last Report, where he asserts, that normally metamorphosed beds are always tilted up on end ; in other words, that only those normally metamorphosed strata are exhibited to our view, which seem to have been elevated from a position of great depth.‡

Where contact metamorphism exists, the alteration being entirely local, and produced by the junction of dissimilar mineral masses, uninfluenced, or at least not necessarily affected, by position—the evidences of altered dip are not always visible, and have generally no connection with the chemical

* Thus Bishof has termed the isothermal planes beneath the surface of the earth.

† Lehrbuch der Geognosie. Vol. I. p. 720–721. 2d. Ed.

‡ May not the fact, that the Pennsylvanian anthracite beds are almost all, if not indeed all, of a very steep dip, have a connection with this fact? The Pennsylvanian anthracite is *normally* metamorphosed, that of Europe only altered by contact.

transformation. Contact metamorphism, however—excepting in regard to the lesson which it may be capable of imparting—is really of very trivial geological importance. There is probably no instance, where the outward metamorphosing action of a dyke-rock is actually capable of being established beyond a very few feet. Very rarely does it exceed a few inches, and far more frequently is no influence of this sort whatever to be detected.

On page 19 of Report III, Cotat's and Fournet's distinction between the outward and inward metamorphic action with dykes, was briefly alluded to. Fournet's terms were employed;—but perhaps it were well to accept the suggestion of Naumann, and inserting the important little word "meta," term the one *exo-metamorphism*, and the other *endo-metamorphism.* Naumann, however, objects to the employment of any distinguishing terms, because, as he remarks, a rock can only then be changed, when it has already first been formed. Hence *endo-metamorphism*, or the marginal transformation of the material of the dyke itself—"a modification produced during the first creation of the pyrogene rock"—could not properly speaking, be at all classed under the head of metamorphism. The distinction being thus withdrawn, there would be no object in retaining any specific designation for the opposite effect.*

Although the propriety of terms in such cases is a matter of comparative unimportance, and its discussion is therefore, generally speaking, better dispensed with, a few words may be passingly devoted to the subject, as it will lead us to more important considerations.

In the first place, even supposing that the alteration was effected upon the mass of the pyrogene rock, during the period of its fluidity, it would not be necessarily incorrect to employ the term. There would yet be a change produced by the character of the rock traversed, and the term leaves the particular state of the dyke-material at the time of such alteration, entirely open to discussion. There is no reason why such endo-metamorphism should not affect a fluid as well as a solid. I mean there is nothing in the term to indicate this. That the gyrating motion of a cooling fluid should equalize such effects, and by distributing them throughout the mass,

* Lehrbuch der Geognosie. 2d. Ed. I. p. 722.

render their results less apparent—this is another matter altogether, and is connected with much more influential inquiries. Perhaps such equalization may really be the cause, or at least a prominent one, of the extreme rarity of any visible effects of endo-metamorphic action.

But recurring to earlier considerations presented in this chapter, the question forces itself upon us, what authority have we to believe that contact metamorphism of either kind, should at all necessarily have been produced at the period of the injection of the intrusive mass? Is it not more likely that in most cases, these contact changes have been produced by entirely subsequent action, and in the humid way? In very few cases are these influences so decided, or so extensive, that a slow aqueous chemical action, even unaided by the stimulating effects of a high temperature, would be insufficient to account for them. Accepting this view, although the scientific importance of the distinction would be greatly diminished, we are justified in admitting the terms for purposes of mere convenience in description. Upon the same grounds would it be proper to designate as *hypo-metamorphism*, those much more uniform and widely distributed changes, produced by comparative depression, to which I have already adverted.

Art. IV.—QUARTZ GOLD MINING IN CALIFORNIA, IN 1858.

The California State Register for the year 1859, published December 15th, 1858, gives much valuable statistical information upon the extent of quartz mining operations in the different counties of the State. The number of quartz mills in operation, in April, 1857, was one hundred and thirty-eight, with an aggregate of fifteen hundred and twenty-one stamps; the cost of erection of which was one million seven hundred and sixty-three thousand dollars. On the first of Nov., 1858, there were two hundred and seventy-nine mills in operation, of which one hundred and nineteen were propelled by steam, one hundred and fifty-three by water, and seven by mule or horse power, with an aggregate of two thousand six hundred and ten stamps. The cost of machinery is estimated at three millions two hundred and seventy

thousand dollars (3,270,000). In addition to the stamps, there were five hundred and nineteen arastras, of which three hundred and ten were connected with different quartz mills, and the remainder were in use in different sections of the quartz region.

A valuable Statistical Table of quartz mills is given in this volume, and occupies nearly five closely printed pages. In this, the date of erection, the number of stamps and arastras, the kind of power used, and the cost of the machinery, are all given.

The following is an abstract of the observations upon quartz mining in some of the principal counties :

Nevada County.—" Grass valley and its vicinity present the most convincing proof of the importance and permanence of the quartz interest of this State. The number of mills in operation is thirty-two, twenty-one of which are propelled by steam and eleven by water. The number of stamps contained in these mills is three hundred and sixteen. Cost of machinery is estimated at $500,000. In addition to the quartz veins immediately connected with the above mills there is a number, probably one hundred, of valuable leads being worked.

" There is no county in the State that has been more worked, and where adventurers have made and lost more money, and where men have become more experienced. Being about the first to engage extensively in the business, this county drew considerable capital to it, that was invested in machinery and leads, much of which became inactive in consequence of wrong calculation and enormous expenses. * * * The Allison Ranch vein, so far, has proved to be the richest quartz lead in the State ; but there are several others in the vicinity of Grass Valley which deserve mention, each having produced a large amount of gold, viz. : Gold Hill, Massachusetts Hill, Osborn hill, Houston Hill, and Lafayette Hill.

" The Allison Ranch vein is situated on Wolf Creek, three miles from Grass Valley, and was first discovered in 1852. The gold was observed to crop out very distinctly from the side of the ledge, but this did not excite much attention, for, at that time, quartz gold-mining was generally regarded by the miners as unprofitable. The company that made this discovery continued to work the bed of the creek until the fall of 1855, when attention was again drawn to the vein by the reports of large yields of quartz in the neighborhood, and

it was at once decided to test its value. Operations were commenced, and the first two or three feet of excavation demonstrated the exceeding richness of the vein. "The first sixty-three tons taken out were sent to a mill in the neighborhood, and yielded the remarkable sum of twenty-two thousand dollars, or three hundred and fifty dollars per ton." They continued to work the vein in this manner until October, 1856, when the company's mill was completed.

"The richness of the quartz is very uniform, and the gold appears to exist throughout the entire claim, which is twelve hundred feet in length. The yield of this mine, since October, 1856, is estimated at one and a half millions of dollars. About eight thousand tons of quartz have been crushed, that have averaged two hundred dollars per ton. What the value of this mine is, no one can estimate; from present appearances, millions of gold will be taken from it. The operations, so far, have scarcely broken its crust; and years of labor will be required to exhaust the quartz, which appears to be almost inexhaustible."

Placer County.—"The number of mills in operation, seventeen; aggregate of stamps, one hundred and forty-four; with thirty-four arastras; cost of machinery, $170,000. Several new and extensive mills have been erected during the past season, nearly every one of which paid the proprietors well."

Tuolumne County.—"The number of mills in operation is thirty, with an aggregate of two hundred and sixty stamps, erected at a cost of $280,000. There are also twenty arastras, of from six to eighteen feet in diameter, erected at a cost of $400 each. The late discoveries made in Tuolumne County, in the mountains east and north of Sonora, show that the mineral wealth of this region is, as yet, but partially developed. Since the discovery of the Platt or Soulsby vein, by Mr. Platt, of this county, the mountains have been covered by parties prospecting for veins of quartz-bearing gold; and, up to this date, there has not been a vein of quartz found in the granite but what bears gold. The belt referred to is about twenty-five miles in width, from northwest to southeast.

"There is water in abundance for the use of the mills, and those in this portion of the county use it (from ditches or canals), as a motive power, and then run it back into the ca-

nal again. By this means miners are able to control twenty-five or thirty horse power for the sum of one to two dollars per day, thus offering great advantages to those engaged in this branch of mining.

"The remarkable claim of Street and Soulsby, the richness of which is said to equal that of the Allison Ranch, is situated in the vicinity of Sonora, and extends a distance of twenty-four hundred feet. It is estimated to contain twenty thousand tons of quartz, that will yield on an average two hundred dollars per ton, equal to $4,000,000. The mill now in operation on the vein has twenty stamps, and is crushing one hundred and fifty tons per week. There are several other valuable leads in the vicinity, that are yielding extraordinary amounts of gold, upon which new and extensive mills have been erected."

Yuba County.—"Number of mills in operation, nine; aggregate number of stamps, eighty; number of arastras, twenty; cost of erection, $80,000. There are several valuable leads in this county, that have yielded large returns during the past season. Recent discoveries have developed an extensive quartz region in the vicinity of Sand Hill, which is reported to be one of the richest in the State."

The statistics for the present year, 1859, will show a large ncrease in the number of quartz-mining establishments, and in the amount of capital invested in this branch of mining.

ART. V.—ON THE METALLURGY OF LEAD.*—By John Arthur Phillips.

Although lead forms an essential element in a large number of minerals, the ores of this metal are, strictly speaking, far from numerous. Of these the most important is sulphide of lead, or galena. This mineral, which possesses a metallic brilliancy, and has a lighter color than metallic lead, presents in its cleavage, all the variations, from large facettes and laminæ indicating a cubic crystallisation to a most minutely granular structure. It is extremely brittle, and its powder presents a brilliant, blackish-grey appearance.

* From the Journal of the Society of Arts, vii. 336

The specific gravity of galena is 7.5 to 7.8, and its composition, when absolutely pure, is:—

Lead	86.55
Sulphur	13.45
	100.00

Galena is, however, but seldom found chemically pure, as, in addition to variable quantities of earthly impurities, it almost always contains a certain amount of silver. It is usually observed that galena presenting large facettes is less argentiferous than those varieties having a closer grain, and thus finely granular steely specimens generally afford the largest amount of silver.

It would appear, from recent experiments, that the silver contained in the finely-granular varieties of galena often occurs in the form of sulphide of silver, mechanically intermixed, whilst in the more flaky descriptions of this ore, the sulphides of lead and silver are chemically combined.

Galena occurs in beds and veins, in granite, gneiss, clay-slate, limestone, and sandstone rocks.

In Spain, it is found in the granite hills of Linares and elsewhere; at Frieberg, in Saxony, it occupies veins in gneiss, in the Hartz, Bohemia, Cornwall, and many other localities, it is found in killas, or clay-slate. The rich deposits of Derbyshire, Cumberland, and the northern districts of England are in the mountain limestone, whilst at Comorn, near Aix-la-Chapelle, large quantities of this ore are found disseminated in the Bunter sandstone.

This mineral is frequently associated with blend, iron and copper pyrites, the carbonate and other ores of lead, and usually occurs in a gangue of sulphate of baryta, calc-spar, spathose iron, or quartz. It is also not unfrequently associated with fluor-spar.

The next most important ore of lead is the carbonate, which is a brittle mineral, of a white or greyish-white color, having a specific gravity varying from 6.46 to 6.50. Its composition is,—

Carbonic acid	16.05
Oxide of lead	83.56
	99.61

Large quantities of this substance occur in the mines of the Mississippi Valley, in the United States of America, where they were formerly thrown away as useless, but have since been collected and smelted. Vast deposits of this substance have also been found in the Bunter sandstone, near Düren, in Prussia, and at Freyung, in Bavaria. In the two latter localities it appears to form the cement holding together the granules of quartz, of which the sandstone principally consists. These ores, which yield from 14 to 20 per cent. of metal, do not readily admit of being concentrated by washing.

The sulphate of lead does not often occur in sufficient quantities to be employed as an ore of that metal. In appearance it is not unlike the carbonate, but may readily be distinguished from it by its not dissolving with effervescene in nitric acid.

Its specific gravity is from 6.25 to 6.30, and its composition—

Sulphuric acid	25.65
Oxide of lead	74.05
	99·70

This ore of lead usually results from the oxidation of galena. At St. Martin's, near the Vega de Ribaddeo, in Spain, this mineral, more or less mixed with the phosphate of lead, is found in sufficient quantities to be made, on a small scale, the subject of an especial metallurgic treatment. Large quantities of sulphate of lead ores are also annually imported into this country from the mines in Australia. These ores contain on an average 35 per cent. of lead and 35 oz. of silver to the ton of ore, together with a little gold.

Phosphate of lead, when crystallised, usually presents the appearance of hexagonal prisms, of a bright-green, brown, or yellowish color. Its specific gravity varies from 6.5 to 7.1. This mineral is composed of a mixture of true phosphate of lead, phosphate of lime, chloride of lead, and fluoride of calcium, and usually contains about 78 per cent. of oxide of lead. In Spain, it occurs in botryoidal forms, in connection with the sulphate of the same metal, and is treated in blast furnaces for the lead it affords.

The other minerals containing lead seldom occur in sufficient quantities to be of much importance to the smelter, and may therefore be disregarded in the present paper.

The extraction and mechanical preparation of ores is the business of the miner, and not of the metallurgist, who receives the ores from the former, freed as perfectly as possible from foreign matters.

The metallurgic processes, by the aid of which lead is obtained from galena, may be divided into two classes. The first of these is founded on the following reactions:—If one equivalent of sulphide of lead and two equivalents of the oxide of the same metal are fused together, the result is three equivalents of metallic lead and one equivalent of sulphurous acid, which is evolved.

This reaction is represented by the following equation:

$$PbS+2PbO=3Pb+SO^2.$$

When, on the other hand, one equivalent of sulphide of lead and one equivalent of sulphate of lead are similarly treated, two equivalents of lead are obtained, and two equivalents of sulphurous acid gas evolved. Thus,

$$PbS+PbO, SO^3=2Pb+2SO^2.$$

The process, founded on the foregoing reactions, and which we will distinguish as the *method by double decomposition*, consists in roasting the galena in a reverberatory furnace until a certain amount of oxide and sulphate has been formed, and subsequently, after having intimately mixed the charge, and closed the doors of the furnace, causing the whole to enter into a state of fusion.

During this second stage of the operation, the reaction between the sulphides, sulphates, and oxides takes place, and metallic lead is eliminated. The roasting of the ore is, in some cases, conducted in the same furnace in which the fusion is effected, whilst in others two separate furnaces are employed.

The process by double decomposition is best adapted for the richer varieties of ore, and such as are least contaminated by siliceous or earthy impurities, and is consequently that which is almost universally employed for smelting the ores of this country.

By the second method, which we will call the *process by affinity*, the ore is fused with a mixture of metallic iron, which by combining with the sulphur, liberates the metallic lead.

This reaction will be understood by reference to the following formula :—

$$PbS+Fe=Pb+FeS.$$

In practice, however, metallic iron is not always employed for this purpose ; cast-iron is also frequently used, and in some instances the ores of iron and hammer slags are substituted, as are also tap-cinder and other secondary products containing a considerable per centage of this metal. None of these substances are, however, found to be so efficacious as metallic iron, since cast-iron requires to be decarburised before it can readily decompose the sulphide of lead, and the ores of iron require the introduction of various fluxes, and the consequent expenditure of an additional amount of fuel. In all cases, however, it is judicious to subject the ore to a preliminary roasting, in order to eliminate a portion of the sulphur, and thereby reduce the expenditure of iron, as well as to agglutinate the ore and render it better adapted for its subsequent treatment in the blast furnace.

I will not attempt to describe the different forms given to roasting furnaces employed for the ores treated by this process, but would remark that they frequently resemble the kilns used for the preparation of lime, whilst in some instances the ores are roasted in heaps interstratified with wood or other fuel.

The method of treating ore by *affinity* is particularly adapted to those varieties that contain a considerable amount of silica, since such minerals, if treated by double decomposition, would, by the formation of oxide of lead, give rise to silicates, from which it would be exceedingly difficult to extract the metal.

English Process.—Treatment by Double Decomposition.—Galena, if placed in a close vessel which protects it from the action of the air, and exposed to a gradually increasing temperature, becomes fused without the elimination of any lead taking place, but ultimately a portion of the sulphur is driven off, and a subsulphide is formed, which at a very elevated temperature is volatilised without change.

If, however, the vessel be uncovered, and the air allowed to act on its contents, oxygen combines with the sulphur, sulphurous acid is evolved, and the desulphuration of the mineral is slowly effected.

When galena is spread on the hearth of a reverberatory furnace, and is so placed as to present the largest possible amount of surface to oxidising influences, it will be found that the surface slowly becomes covered with a yellowish-white crust of sulphate of lead. The oxygen of the air, by combining with the two elementary bodies of which galena is composed, will evidently produce this effect. This is not, however, the only chemical change which takes place in the charge under these circumstances; oxide of lead is produced at the same time as the sulphate, or rather the formation of the oxide is prior to that of the sulphate.

In fact, during the first stage of the operation of roasting, sulphurous acid is evolved, the sulphur quits the lead, and a portion of that metal remains in a free state. This becomes oxidised by the air passing through the furnace, and subsequently a part of it combines with sulphuric acid, formed by the oxidation of sulphurous acid, and sulphate of lead is the result. In this way, after the expiration of a certain period, both oxide and sulphate of lead are present in the furnace.

During the early period of the roasting, when the temperature of the furnace is not very elevated, the proportion of sulphate is larger than that of the oxide formed, but in proportion as the heat of the apparatus increases, the production of oxide becomes more considerable, whilst that of the sulphate diminishes.

The sulphate and oxide thus formed re-act in their turn on the undecomposed galena, whilst a portion of the latter, by combining with the sulphide of the lead, gives rise to the formation of oxysulphides.

This last compound has no action on galena, except to dissolve it in certain proportions, but is readily decomposed by the aid of carbonaceous matters.

It is therefore evident that the addition of carbon, at this stage of the operation, will have the effect of reducing the oxide and oxysulphide of lead.

Every process then that has for its object the reduction of lead ores by double decomposition, comprises two principal operations. 1st. The reduction of galena, by the aid of heat and atmospheric air, to a mixture of sulphide, oxide, and sulphate, which mutually decompose each other with the elimination of metallic lead. 2nd. The reduction of the oxysulphide by the addition of carbonaceous matter.

THE REVERBERATORY FURNACE.—The reverberatory furnace employed for the treatment of galena is composed, like all other furnaces of this description, of three distinct parts, the fire-place, the hearth, and the chimney.

The hearth has to a certain extent the form of a funnel, of which the lowest point is on the front side of the furnace immediately below the middle door. The molten metal descending from every side along the inclined bottom or sole, is collected in this receptacle, and is ultimately run off by means of a proper tap-hole. This tap-hole is, during the operation, closed by a pellet of clay.

The inclination of the hearth is more rapid in the vicinity of the fire-bridge than towards the chimney, in order that the liquid metal may not be too long exposed to the oxidising and volatilising influences of a current of strongly-heated air.

The dimensions given to these furnaces, as well as the weight of the charge operated on at one time, vary considerably in different localities, but in the north of England the following measurements are usually employed: The fire grate is 5ft. 9in. × 1ft. 10in., and the thickness of the fire-bridge 1ft. 6in.; the length of the sole is 9ft., and its average width 7ft. The depth of the tap is about 2ft. 6in. below the top of the inclined sole. The height of the roof at the fire-end may be 1ft. 4in., and at the other extremity 11 inches.

The introduction of the charge is in some cases effected by the doors of the furnace, whilst in other instances a hopper, placed over the centre of the arch, is made use of.

On the two sides of the furnace are placed three doors about 11in. × 9in., which are distinguished as 1, 2 and 3, counting from the fire-bridge end. The three doors on the one side are known as the front-doors, whilst those on the other side are called the back-doors. Immediately beneath the door on the front side of the furnace is situated the iron pan into which the molten lead is tapped off.

The bottom of this arrangement is in most cases composed of fire-bricks, covered by a layer of vitrified slags, of greater or less thickness. In order to form this bottom, the slags are introduced into the furnace, the doors closed, and the damper raised. An elevated temperature is thus quickly obtained, and as soon as the scoriæ have become sufficiently fused, they are, by means of rakes and paddles, made to assume the required form. The charge employed, as before stated, varies in almost every establishment. In the North, however,

smaller charges are used than most other localities. At Newcastle, and in the neighborhood, the charge varies from 12 to 14 cwt.; in Wales, and near Bristol, 21 cwt. charges are treated; whilst in Cornwall, charges of 30 cwt. are not unfrequently worked. The time required for smelting a charge varies with its weight and the nature of the ores, from 6 to 24 hours.

In some cases the ore is introduced raw into the furnace, whilst in others it undergoes a preliminary roasting previous to its introduction. Rich ores are generally smelted without being first calcined, but the poorer varieties, and particularly those which contain large quantities of iron pyrites, are, in most instances, subjected to roasting in a separate furnace.

In order to understand more clearly the operation of smelting in furnaces of this description, we will suppose that a charge has just been tapped off, and that, after thoroughly clearing the hearth, a fresh charge of raw ores has been introduced. During the first part of the operation of roasting, which usually occupies about two hours, the doors are taken off to admit free access of air, and also for the purpose of cooling the furnace, which has been strongly heated at the close of the preceding operation. No fuel is at this period charged upon the grate, since the heat of the furnace is of itself sufficient to effect the elimination of the first portions of sulphur. The ore is carefully stirred, for the purpose of constantly presenting a fresh surface to oxidising influences, and when white fumes are no longer observed to pass off in large quantities, a little coal may be thrown on the grate, and the temperature gradually elevated until the charge becomes slightly clammy and adheres to the rake. When the roasting is considered as being sufficiently advanced, the smelter turns his attention to the state of the fire, taking care to remove the clinkers and get the grate into proper condition for the reception of a fresh supply of fuel. The furnace doors are now closed, and a strong beat is kept up for about a quarter of an hour, when the smelter examines the condition of his charge by removing one of the doors. If the operation is progressing satisfactorily, and the lead flowing freely and passing without obstruction into the tap, the firing is continued a little longer; but when the ores have been found to have taken fire, or are lying unevenly on the bottom of the furnace, the position of the charge is changed by the use of an

iron paddle. During this operation the furnace becomes partially cooled, and the reduction of temperature thus obtained is frequently found to produce decompositions, which facilitate the reduction of the charge. In the case of extremely refractory ores this alternate heating and cooling of the furnace is sometimes almost indispensable, whilst, in other instances, their being raked over once or twice, is all the manipulation that is required.

We will suppose that four hours have now elapsed since the charging of the furnace, and that the charge has run down the inclined sole towards the tap. The smelter now examines the condition of the scoriæ and adds a couple of shovelfuls of lime and three or four shovelfuls of small coals, the amount and relative proportions of these being regulated in accordance with the aspect of the slags. The charge is now, by means of proper tools, again raised to the breast of the furnace, and the firing continued until the charge has run down into the tap-hole. The foreman now takes his rake and feels if any lumps remain in an unfused condition, and if he finds all to be in a fluid state he calls his assistant from the other side, and, by the addition of a small quantity of lime and fine coal, makes the slag assume a pasty or rather doughy consistency. By the aid of his paddle he now pushes this compound up to the opposite side of the furnace, where it is drawn by an assistant through the back door into a trough containing water. Whilst the assistant is doing this, the foreman is busily engaged in tapping off the metal into the iron pan in front of the furnace, from which, when sufficiently cooled, it is laded out into suitable moulds.

The total duration of the operation may be about six hours.

To build a furnace of the above description, 5,000 common bricks, 2,000 fire bricks, and 2½ tons of fire-clay are required. In addition to this must be reckoned the iron-work, the expense ot which will be much influenced by the nature of the armatures employed and the locality in which the furnace is constructed.

The amount of fuel employed for the treatment of a ton of lead ore varies not only in relation to the richness of the mineral, but is also much influenced by the nature of the associated matrix and the calorific value of the fuel itself. The loss of metal experienced during the operation is mainly de-

pendent on the richness of the ore treated and the skill and attention of the foreman.

In the North about 12 cwt. of coal are consumed in the elaboration of one ton of ore, and the loss of metal on 60 per cent. ore may be estimated at about 12 per cent., of which about 6½ per cent. is subsequently recovered from the slag and fumes. At a well-conducted smelting works, situated in the west of England, in which the average assay of the ores smelted during the year was 75½, the yield from the smelting furnaces was 68½ per cent., and the coal used per ton of ore was 13¾ cwts. The lead recovered from the slag and fumes amounted to 2¾ per cent., making the total yield of metal 71¼ per cent., and the loss on the assay produce 4½ per cent.

In this establishment the men are paid from 7s. 6d. to 12s. 6d. per ton of lead, in accordance with the nature of the ores operated on.

In one establishment the process before described is somewhat varied. The charge employed is 21 cwt. This is run down and tapped off at the expiration of 6 hours, and about nine pigs of 1¼ cwt. each, usually obtained. A second charge of 21 cwt. is then dropped in, and, as soon as it is roasted, mixed with the slags of the former operation. The whole is then run down in the ordinary way, the slags drawn and the lead tapped off in nine hours. The produce of the second or double charge is from 14 to 15 pigs.

If the ores are difficult to flow, 16 to 16½ hours are required for the two charges. A small quantity of black slag from the slag hearth is employed for drying up.

Slag Hearth.—The various slags obtained from the different operations of lead smelting are divided into two classes. Those which do not contain a sufficient amount of metal to pay for further treatment are thrown away as useless, whilst those in which the per centage of lead is sufficiently large are treated by the slag hearth.

This consists of a small blast furnace, having the form of a rectangular prism, about 25 inches in length, 22 inches in breadth, and 33 inches in height. The bottom is composed of a thick cast-iron pan, which is made to incline slightly from the tuyere towards the breast of the furnace. Cast-iron bearers are placed on each side of the iron plate, and on these is supported the fore-hearth, which consists of two stout

plates of cast-iron. A space of about 5 inches is thus left between the front and bottom of the furnace, and an additional height of 2½ inches is obtained by placing between them a row of fire-bricks laid on their flat.

The slags escaping through the opening in the breast of this arrangement sometimes flow into a cistern of water sunk in the earth. This causes the slags to divide into small fragments, and thus adapts them for the process of washing, when it is intended to subject them to this operation. Before starting a furnace of this description, its bottom is filled to a depth of a foot or fifteen inches with small spongy cinders rather closely packed together, and which reach to within four or five inches of the orifice of the tuyere; the breast pan is also filled with cinders, which are intended to act as a kind of filter in the separation of metallic lead from the slags. The furnace is frequently lighted by the aid of a small quantity of peat, and when this has become fairly ignited, some good hard coke is thrown in, and as soon as it appears to be sufficiently inflamed, a stratum of gray slag or any other substance to be treated, is introduced. From this time, the hearth is supplied with alternate strata of fuel and slag. The lead obtained from the slag hearth is, from the high temperature at which it is produced, always harder, and therefore inferior in quality to that procured directly from the ores in the reverberatory furnace, and this process is consequently never applied to the treatment of products that admit of being economically worked by the furnace before described.

In addition to being employed for the reduction of slags, this apparatus is sometimes applied to the elaboration of ores of low produce, in the treatment of which the object sought is rather the extraction of the silver they contain, than the reduction of the largest possible amount of lead.

Instead of being blown by a cold blast, these furnaces are sometimes supplied with heated air. When smelting with cold air, it is often found difficult to proportion the quantity of slag or other substance operated on, so as to preserve the nose or cone of slag which forms at the end of the tuyere from growing too long, to the prejudice of the operation. When the substance operated on is poor for metal, and very refractory, it frequently happens that the smelter is obliged to break the nose, or introduce some very fusible substance in order to melt it off. By the introduction of hot air this inconvenience

is removed, since by increasing or lowering the temperature of the blast, the nose may be allowed to lengthen or shorten, according as the nature of the slags may require. The temperature found to answer best is from 250° to 300° Fahr.; since when it is heated to from 500° to 600°, it is found impossible to form a nose of sufficient length to convey the blast to the front of the hearth, and therefore the back, which is expensive to rebuild, is quickly destroyed.

The advantage to be derived from the use of the hot blast will be evident, from the result of two experiments which were tried some years since.

Twenty-eight tons of slag smelted with cold blast consumed 392 cubic feet of air per minute.

Labor cost	£3	7	8
Coke, 7 tons, at 24s. 6d.	8	11	6
Total	£11	19	2

Thirty-five tons of similar slag smelted with hot blast consumed 300 cubic feet of air per minute.

Labor cost	£3	7	8
Coke, 5 tons, 17 cwt., at 24s. 6d.	7	3	4
Turf for heating air, 11 loads, 1s. 8d.	0	18	4
Total	£11	9	4

From which it will be seen that, with one-quarter part less air, a quarter part more slag was melted per week, and a saving in expense of 10s. effected.

The loss of lead experienced in smelting by the slag hearth is, however, very great, even under the most favorable circumstances; and it has consequently, of later years, been gradually superseded by the Castilian furnace, which will be shortly described. Many large and well-conducted establishments still, however, continue to employ the slag hearth, and, when well constructed and skilfully managed, the loss arising from volatilization may be considerably reduced.

Scotch Hearth.—Instead of the reverberatory furnace, the Scotch hearth may frequently be employed with advantage for the treatment of lead ores of a good produce. This consists of a rectangular cavity, lined with cast-iron, and of which the dimensions vary in different localities, although it is frequently made about 2 ft. square.

The bottom is also of cast-iron, and is surrounded by a ledge about five inches in height, with the exception of the side nearest the work-stone, which is of iron, and may be about 20 inches in breadth. This plate is made to have a fall of about six inches on its whole breadth; its upper side rests on the hearth-bottom, or in some instances is united with it, only forming one casting. On the back edge of the furnace bottom is placed a prism of cast-iron, called a back-stone, and on this rests the nozzle of the tuyere, over which is again placed another block of the same metal, called a pipe-stone, and on this again is placed another back-stone, which completes this side of the hearth. Along the two lateral edges of the hearth-bottom are laid two prismatic castings, called bearers, which project slightly over the upper edge of the work-stone. Above these bearers is a prism of cast-iron called a fire-stone, the space at each end being closed by cubes of cast-iron called key-stones.

Before the work-stone, and set in masonry, is the lead-pot, into which the melted metal as it issues from the hearth, is conducted by an oblique channel sunk beneath the surface of the iron plate. To prevent the escape of fumes into the smelting-house, the whole is covered by a hood of arched bricks, which is provided with a sheet-iron front. The blast introduced through the tuyere is regulated by a throttle-valve, and the brick-work is consolidated and bound together by heavy iron straps, kept in their places by screw-bolts passing through the masonry. The ores treated in the Scotch hearth are usually roasted in a separate furnace, for the purpose of effecting their partial desulphuration and oxidation before undergoing the process of smelting.

At the termination of every shift, a quantity of ore remains on the hearth in a semi-reduced state called browse, and is more or less mixed with fragments of coke and clinker, from which it is afterwards roughly separated.

To commence a new shift, the cavity of the furnace is filled with peat cut into blocks; those at the back are heaped up without any kind of order, but those towards the front are arranged in the shape of a wall. The blast is now turned on, and an ignited fragment of peat thrown immediately before the nozzle, which quickly communicates combustion to the whole mass. On the top of this a few shovelfuls of coal are subsequently placed, and the browse resulting from the pre-

ceding operation is then charged on the top of the ignited mass, and shortly afterwards a portion of the molten matter in the internal basin is drawn on to the work-stone. The gray slag is now removed, and thrown on one side of the furnace, and the browse, thus freed from slag, again returned to the hearth, with the addition of a little coal. If, as is sometimes the case, it has not been properly freed from slag, and therefore exhibits a disposition to fuse, it must be hardened by the addition of a small quantity of quicklime, which dries up the materials in such a way as to facilitate the subsequent extraction of the lead. When, on the contrary, the ore is found too refractory, a small quantity of lime, or of lime and fluor-spar, is added, but in this case a less amount of lime is employed, as it is intended as a flux and not as a drier of a too fusible slag. The slag thus obtained still contains a notable amount of lead, and is subsequently treated in the slag hearth.

When the whole of the browse has been thrown back into the hearth, a few shovelfuls of roasted ore are distributed over it; before doing this, however, the scoriæ are removed, and a lump of peat is placed before the tuyere, which not only prevents any of the mineral from entering the nozzle, but also, from its porosity, seems to equalize and distribute the air through the mass.

After another interval of about twenty minutes, the contents of the hearth are again drawn out on the work-stone, and another portion of metallic lead obtained. The gray slag is removed, and another lump of peat placed before the tuyere; the browse, together with a proper quantity of coal and quick lime, is again thrown upon the fire, and on the top is laid a fresh supply of roasted ore. The Scotch hearth will, in accordance with the nature of the ore treated, yield from one to two tons of metallic lead per shift, and usually affords softer metal than the reverberatory furnace.

In an establishment in the North, where the Scotch hearth is employed, and in which the ores treated contain on an average 73 per cent. of metal, the following results are obtained:—

The lead reduced at the first fire amounts to 60 per cent., but 3.20 per cent. are subsequently obtained from the slags, and 6.91 per cent. from the fumes, making the ultimate loss on the assay produce 2.90 per cent.

The materials employed for the elaboration of one ton of ore are as follows :—

	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.
Coals for smelting......	1	2	4	3	1	15
" calcining.....	1	3	11			
Peat or turf...........				0	3	0
Lime..................				0	2	0
Total				4	2	15

To construct an ore hearth 2000 common bricks, and the same quantity of fire-bricks, are required, together with about $1\frac{1}{2}$ tons of fire clay.

Castilian Furnaces.—Within the last few years a blast furnace has been introduced into the lead works of this country, which possesses great advantages over every other description of apparatus which has been hitherto employed for the treatment of lead ores of low produce. This apparatus, although first employed in Spain, was, as I am informed, invented by an Englishman (Mr. W. Goundry) who was employed in the reduction of rich slags in the neighborhood of Carthagena.

This furnace is circular, usually about 2 feet 10 inches, or 3 feet in diameter, and is constructed of the best fire-bricks, so moulded as to fit together, and allow all the joints to follow the radii of the circle described by the brickwork. Its usual height is 8 feet 6 inches, and the thickness of the masonry invariably 9 inches. In this arrangement the breast is formed by a semi-circular plate of cast-iron, furnished with a lip for running off the slag, and has a longitudinal slot, in which is placed the tapping-hole.

On the top of this cylinder of brickwork a box-shaped covering of masonry is supported by a cast-iron framing, resting on four pillars, and in this is placed the door for feeding the furnace, and the outlet by which the various products of combustion escape to the flues. The lower part of this hood is fitted closely to the body of the furnace, whilst its top is closed by an arch of $4\frac{1}{2}$ inch brickwork laid in fire-clay. The bottom is composed of a mixture of coke-dust and fire-clay, slightly moistened, and well-beaten to the height of the top of the breast-pan, which stands nearly 3 feet above the level of the floor. Above the breast-pan is an arch, so turned as to form a sort of niche, 18 inches in width, and rather more than 2 feet in height.

When the bottom has been solidly beaten, up to the required height, it is hollowed out so as to form an internal cavity, communicating freely with the breast-pan, which is filled with the same material and subsequently hollowed out to a depth slightly below the level of the internal cavity. The blast is supplied by three water tuyeres, 3 inches in diameter at the smaller end, 5½ inches at the larger, and 10 inches in length. Into these the nozzles are introduced, by which a current of air is supplied by means of a fan or ventilator, making about 800 revolutions per minute. The blast may be conveniently conducted to the nozzle through brick channels formed beneath the floor of the smelting house.

The ores treated in this furnace ought never to contain more than 30 per cent. of metal, and when richer, must be reduced to about this tenure by the addition of slags and other fluxes. In charging this apparatus, the coke and ore are supplied stratum super stratum, and care must be taken so to dispose the coke as not to heat too violently the brickwork of the furnaces.

In order to allow the slags which are produced to escape freely into the breast-pan, a brick is left out of the front of the furnace at the height of the fore-hearth, which, for the purpose of preventing the cooling of the scoriæ, is kept covered by a layer of coke-dust or cinders. From the breast-pan the slags flow constantly off over a spout into cast-iron waggons, where they consolidate into masses, having the form of truncated pyramids, of which the larger base is about 2 feet square. As soon as a sufficient amount of lead has accumulated in the bottom of the furnace, it is let off into a lateral lead pot, by removing the clay stopper of the tap hole situated in the slot of the breast-pan, and after being properly skimmed it is laded into moulds. When in addition to lead the ore treated likewise contains a certain portion of copper, this metal will be found in the form of a matt floating on the surface of the leaden bath. This, when sufficiently solidified, is removed, and after being roasted is operated on for the copper it contains.

The waggons which the liquid slag runs off, are frequently made to traverse small railways, by which, when one mass has been removed, its place may readily be supplied by an empty waggon. When nearly cold the casings of the waggons are turned over and the blocks of slag easily made to drop out.

In addition to the facility for transport obtained in this way, one of the great advantages obtained by this method of manipulation arises from the circumstance that should the furnaces at any time run lead or matt, without its being detected by the smelter, the whole of it will be collected at the bottom of the block, from which, when cold, it may be readily detached.

In working these furnaces, care must be taken to prevent flame from appearing at the tunnel-head, since, provided the slags are sufficiently liquid, the cooler the apparatus is kept the less will be the loss of metal through volatilization. In addition to the greatest attention being paid to the working of the furnace, it is necessary, in order to obtain the best results, that all establishments in which this apparatus is employed should be provided with long and capacious flues, in which the condensation of the fumes takes place, previous to arriving at the chimney-shaft. These flues should be built three feet in width, and six feet in height, so as readily to admit of being cleaned, and are often made of several hundred feet in length. The value of the fumes, so condensed, amounts to many hundreds, and in some instances thousands per annum.

In order to be advantageously worked in these furnaces, the ores should be first roasted, and subsequently agglomerated into masses, which, after being broken into fragments, of about the size of the fist, and mixed with the various fluxes, are charged as before described.

In an establishment in which the average assay produce of the roasted ore for lead is $42\frac{4}{5}$ths, the furnace yield is $38\frac{13}{14}$ths, and the weight of coke employed to effect the reduction 22 per cent. of the roasted ore operated on. The mixture charged into the furnace, in this instance, is composed of 100 parts of roasted ore, 42 parts of slag, from a previous operation, 8 parts of scrap iron, and 7 parts of limestone. Each furnace works off about seven tons of roasted ore in the course of 24 hours; the weight of slags run off is about double that of the lead obtained, and the matt removed from the surface of the pan is nearly 5 per cent. of the lead produced. The ores treated in this establishment consist of galena, much mixed with spathose iron, and are therefore somewhat refractory. A furnace of this kind requires for its construction about 1200 segmental fire-bricks, and the same number of ordinary fire-bricks of second quality.

The desulphuration of the ores to be treated in these fur-

naces may be effected either by the aid of an ordinary reverberatory roasting furnace, or in heaps, or properly constructed kilns.

The kilns best adapted for this purpose consist of rectangular chambers having an arched roof, and provided with proper flues for the escape of the evolved gases, as well as a wide door for charging and withdrawing the ore to be operated on.

Each of these chambers is capable of containing from 25 to 30 tons of ore, and in order to charge it a layer of fagots and split wood is laid on the floor, and this, after having been covered by a layer of ore, about two feet in thickness, is ignited, care being, at the same time, taken to close, by means of loose brick-work, the opening of the door to the same height. When this first layer has become sufficiently ignited, a fresh stratum of ore, mixed with a little coal or charcoal, is thrown upon it, and when this layer has, in its turn, become sufficiently heated, more ore is thrown on. In this way more ore is every day added, until the kiln has become full, when the orifice of the doorway is closed by an iron plate, and the operation proceeds regularly and without further trouble until the greater portion has become eliminated.

This usually happens at the expiration of about four weeks from the time of first ignition, and the brick-work front is then removed, and the ores broken out, and after being mixed with proper fluxes, passed through the blast furnace.

The proportion of wood necessary for the roasting of a ton of ore by this means must necessarily depend on the composition of the minerals operated on, but with ores of the description above mentioned, and in the neighborhood where wood is moderately cheap, the desulphuration may be effected at a cost of about 5s. per ton.

Calcining.—The lead obtained by the various processes above described generally contains a sufficient amount of silver to render its extraction of much importance ; but, in addition to this, it is not unfrequently associated with antimony, tin, copper, and various other impurities, which require to be removed before the separation of the silver can be effected.

This operation consists in fusing the hard lead in a reverberatory furnace of peculiar construction, and allowing it to remain, when in a melted state, exposed to the oxidizing influences of the gases passing through the apparatus. By this treatment the antimony, copper, and other impurities become

oxidized, and on rising to the surface of the metallic bath are skimmed off, and removed with an iron rake. The hearth of the furnace in which this operation is conducted consists of a large cast-iron pan, which may be 8 feet in length, 5 feet 6 inches in width, and 10 inches in depth. The fire-place, which is 1 foot 8 inches in width, has a length equal to the width of the pan, and is separated from it by a fire-bridge 2 feet in width. The height of the arch at the bridge end is 1 foot 4 inches above the edge of the pan, whilst at the outer extremity it is only about 8 inches.

The lead to be introduced into the pan is first fused in a large iron pot fixed in brick-work at the side of the furnace, and subsequently ladled into it through an iron gutter adapted for that purpose. The length of time necessary for the purification of hard lead obviously depends on the nature and amount of the impurities which it contains; and, consequently, some varieties will be sufficiently improved at the expiration of twelve hours, whilst in other instances it is necessary to continue the operations during three or four weeks. The charge of hard lead varies from eight to eleven tons.

When the metal is thought to be in a fit state for tapping, a small portion taken out with a ladle, and poured into a mould used for this purpose, is found on cooling to assume at the surface a peculiar crystallized appearance, which when once seen is readily again recognized. As soon as this appearance presents itself, an iron plug is withdrawn from the bottom of the pan, and the lead run off into an iron pan, from which it is subsequently laded into moulds.

The items of cost attending the calcination of one ton of hard Spanish lead in the north of England are about as follows:—

	s.	*d.*
Wages	1	11.2
Coals 2.7 cwt.		4.7
Repairs, &c.	1	0.5
	3	4.4

The construction of a furnace of this description requires 5000 common bricks, 3500 fire-bricks, and 2 tons of fire clay.

(*To be Continued.*)

ART. VI.—OBSERVATIONS ON THE OCCURRENCE OF GOLD.*— By FREDERICK A. GENTH.

MUCH has been said and written about the occurrence of gold in veins and elsewhere, and the formation of the same; but, comparing the different theories with some very important facts, we are often at a loss to explain the latter satisfactorily, and it seems to me that we know but very little about this difficult subject. Without any intention to discuss the merits of the different theories, I will give in the following a few data, which may help to throw some light on this question.

Gold is frequently found in diorite (in smaller quantities in syenite and granite); and, although it is only rarely observed in the massive rocks, I have seen specimens from Honduras, C. A., where it was imbedded in the diorite without any other association. The result of the complete decomposition of the diorite is generally a red clayish soil, and this has in the gold region of North Carolina, etc., a high reputation for its richness in gold. It was in the diorite region of Cabarrus county, N. C., where the first large piece of gold was found, weighing twenty-eight pounds. All this soil is more or less auriferous, but containing the gold somewhat concentrated, nearly in the same ratio in which the lighter particles have been washed away. But not only in this country the diorite has been found to be auriferous, as is proved by the large piece of eighty-six pounds which was found at Alexandrowsk near Miask in Siberia, nine feet below the surface, in diorite.

The gold obtained from the disintegrated diorite is generally smooth and rounded as if it was water-worn. This cannot be, however, because it lies still in its original, but only altered matrix, and has not been subjected to any attrition by water and sand; besides, if we observe any cavities in such gold, we find the sharp edges of crystals, etc., in the same, rounded in a similar manner, just as if the whole piece had been subjected to the action of acids, which in reality seems to have been the case. I believe that this is the most natural explanation, because it tells us, at the same time, to what

* Extract from "Contributions to Mineralogy, by Frederick A. Genth." Amer. Jour. Sci. xxviii. Sept. 1859.

source we must trace the gold, which we find in the veins passing through these formations.

The greatest difficulty presents itself by inquiring into the nature of the solvent. I do not believe it is very probable that the gold has been carried off as a silicate of gold, or by the action of chlorhydric acid upon the sulphid. What seems to me most reasonable, is that it was dissolved as terchlorid of gold. If we remember, that the decomposition of pyrites, one of the most common accessory constituents of diorite, produces sulphuric acid, which, in the presence of the never-wanting chlorid of sodium and a higher oxyd of manganese, may liberate small quantities of chlorine, the most powerful solvent of gold, we have at least a very plausible explanation.

After penetrating the decomposed diorite, the solution of gold, passing down the veins, comes in contact with reducing agents, and is reprecipitated again, frequently in crystals or crystalline forms. I shall farther below make a few remarks about the substances which precipitate the gold, in veins as well as in beds.

An almost positive proof that the gold in the veins of the diorite formation originates from the adjoining rocks, is the fact that the deeper the diorite is decomposed, the deeper the gold is found in the veins. Many of these veins do not contain any gold at fifty feet depth; and I have known veins, which were rich near the surface, not to contain a trace of gold at thirty-five feet depth. Very few of these veins (if not on high hills) carry any gold below 120 feet depth.

The occurrence of gold in beds in the metamorphic slates at great depth can far more be relied upon; Gold Hill, in Rowan co., N. C., for instance, is over 600 feet deep, and the ore as rich as ever. Although it cannot be denied that the greater portion of the gold in such deposits is as old as the stratum itself, in which it occurs, it is certain that inside of such auriferous strata constant changes are going on, gold dissolved and reprecipitated. We could not account for the crystalline structure of most of the gold in such beds, if we would not presume that the freshly precipitated gold deposits frequently *upon* that already present.

The description of a few specimens in my collection may be interesting, for they prove that the gold *must* have been in solution.

a. From Whitehall, Spottsylvania co., Va.,—shows gold associated with tetradymite, limonite and quartz. The gold is crystallized in forms belonging to the rhombohedral system, and showing very distinctly one rhombohedron, scalenohedron and basal plan; it is coating tetradymite and evidently a pseudomorph after it. I have seen other specimens from the same locality, but of inferior value and beauty.

b. The tetradymite from the Tellurium Mine, Fluvanna co., Va., and the native bismuth from the Peak of the Sorato in Bolivia, S. A., are frequently interlaminated with gold.

I have made some experiments with a solution of terchlorid of gold and tetradymite, and found that the latter precipitates the gold from a dilute solution easily with a smooth and brilliant surface.

c. In the upper portion of the ore bed in the metamorphic slates at Springfield, Carroll county, Md., which, near the surface, consists of magnetite and at a greater depth of chalcopyrite and other ores, sometimes films of native gold have been observed coating the cleavage planes of magnetite. On close examination, it can be noticed that below the film of gold the magnetite is oxydized into hydrated sesquioxyd of iron.

d. A very striking occurrence of native gold, is that where it is associated with pyrites. Most of the pyritous gold ores are too poor to form a positive opinion about the form, in which they contain the gold, from observation, and many authors are of opinion that the gold may exist in the form of a sulphid, either by itself or as a sulphosalt. If we take it for granted that the pyrites itself is the result of the reduction of iron-salts, and bear in mind that protosalts of iron reduce gold *instantaneously*, we cannot adopt this opinion. But even if terchlorid of gold should have been precipitated by sulphydric acid, whilst passing through the vein, it could not remain in that state for a long time, because moist tersulphid of gold in the presence of the smallest trace of an acid is easily decomposed into metallic gold and sulphuric acid. Some specimens of auriferous albite from Winter's vein, Calaveras county, California, show beautifully that, wherever there is a crystal of pyrites, small crystals of gold are attached to it, demonstrating that the sulphate of iron precipitated the gold, previous to its own reduction into pyrites.

All these facts prove that the gold is carried into the veins

from the adjoining rocks, and that the opinion, which considers veins the source of the gold of alluvial and diluvial deposits and the soil, is erroneous.

If another proof was wanted to show the fallacy of this idea, it would be the fact that the gold from the soil or alluvial and diluvial deposits, has rarely the same fineness as that from the veins wrought in the immediate neighborhood of the same, the latter being generally less fine. It is impossible, therefore, that the destruction of a portion of these veins could have furnished the gold of such deposits.

MINING AND SCIENTIFIC INTELLIGENCE.

GEOLOGY.

*British Association for the Advancement of Science.**—The twenty-ninth meeting of this Association was opened at Aberdeen, September 14th, under the Presidency of his Royal Highness the Prince Consort. A resolution was adopted, limiting the number of associate members to two thousand, as there were not accommodations in the hall for more. This number of tickets was speedily sold. Places of public interest were thrown open to members, and several excursions were enjoyed. At the General Meeting, in the evening, the opening address of the Royal President was delivered.

The various sections were organized on the day following; that of Geology, being under the presidency of Sir Charles Lyell. In his opening address, he said :—

"No subject has lately excited more curiosity and general interest among geologists and the public than the question of the antiquity of the human race; whether or not we have sufficient evidence to prove the former co-existence of man with certain extinct mammalia, in caves, or in the superficial deposits commonly called drift or '*diluvium.*' For the last quarter of a century the occasional occurrence in various parts of Europe of the bones of man, or the works of his hands, in cave-breccias and stalactites, associated with the remains of the extinct hyæna, bear, elephant, or rhinoceros, have

* Compiled from the "Athenæum" and "Geologist."

given rise to a suspicion that the date of man must be carried further back than we had heretofore imagined. On the other hand, extreme reluctance was naturally felt on the part of scientific reasoners, to admit the validity of such evidence, seeing that so many caves have been inhabited by a succession of tenants, and have been selected by man as a place not only of domicile, but of sepulture, while some caves have also served as the channels through which the waters of flooded rivers have flowed, so that the remains of living beings which have peopled the district at more than one era may have subsequently been mingled in such caverns and confounded together in one and the same deposit. The facts, however, recently brought to light during the systematic investigation, as reported on by Dr. Falconer, of the Brixham Cave, must, I think, have prepared you to admit that scepticism in regard to the cave evidence in favor of the antiquity of man had previously been pushed to an extreme. To escape from what I now consider was a legitimate deduction from the facts already accumulated, we were obliged to resort to hypotheses requiring great changes in the relative levels and drainage of valleys, and, in short, the whole physical geography of the respective regions where the caves are situated—changes that would alone imply a remote antiquity for the human fossil remains, and make it probable that man was old enough to have co-existed at least with the Siberian mammoth. But in the course of the last fifteen years another class of proofs have been advanced in France in confirmation of man's antiquity; into two of which I have personally examined in the course of the present summer, and to which I shall now briefly advert. First, so long ago as the year 1844, M. Aymard, an eminent palæontologist and antiquary, published an account of the discovery in the volcanic district of Central France of portions of two human skeletons (the skulls, teeth, and bones) embedded in a volcanic breccia found in the mountain of Denise, in the environs of Le Puy en Velay; a breccia anterior in date to one at least of the latest eruptions of that volcanic mountain. On the opposite side of the same hill the remains of a large number of mammalia, most of them of extinct species, have been detected in tufaceous strata, believed, and I think correctly, to be of the same age. The authenticity of the human fossils was from the first disputed by several geologists, but admitted by the majority of those who visited Le Puy and saw with their own eyes the original specimen now in the museum of that town. Among others M. Pictet, so well known to you by his excellent work on palæontology, declared, after his visit to the spot, his adhesion to the opinions previously expressed by Aymard. My friend, Mr. Scrope, in the second edition of his 'Volcanos of Central France,' lately published, also adopted the same conclusion, although after accompanying me this year to Le Puy, he has seen reason to modify his views. The result of our joint examination, a

result which I believe essentially coincides with that arrived at by M. Hébert and M. Lartet, names well known to science, who have also this year gone into this inquiry on the spot, may thus be stated. We are by no means prepared to maintain that the specimen in the museum at Le Puy (which unfortunately was never seen *in situ* by any scientific observer) is a fabrication. On the contrary, we incline to believe that the human fossils in this and some other specimens from the same hill were really embedded by natural causes in their present *matrix*. But the rock in which they are entombed consists of two parts, one of which is a compact, and for the most part thinly laminated stone, into which none of the human bones penetrate; the other containing the bones is a lighter and much more porous stone without lamination, to which we could find nothing similar in the mountain of Denise, although both M. Hébert and I made several excavations on the alleged site of the fossils. M. Hébert therefore suggested to me that this more porous stone, which resembles in color and mineral composition, though not in structure, parts of the genuine old breccia of Denise, may be formed of the older rock broken up and afterwards re-deposited, or as the French say, *remané*, and therefore of much newer date—an hypothesis which well deserves consideration; but I feel that we are at present so ignorant of the precise circumstances and position under which these celebrated human fossils were found, that I ought not to waste time in speculating on their probable mode of interment, but simply declare that in my opinion they afford no demonstration of man having witnessed the last volcanic eruptions of Central France. The skulls, according to the judgment of the most competent osteologists who have yet seen them, do not seem to depart in a marked manner from the modern European, or Caucasian type, and the human bones are in a fresher state than those of the *Elephas meridionalis* and other quadrupeds found in any breccia in Denise, which can be referred to the period even of the latest volcanic eruptions. But while I have thus failed to obtain satisfactory evidence in favor of the remote origin assigned to the human fossils of Le Puy, I am fully prepared to corroborate the conclusions which have been recently laid before the Royal Society by Mr. Prestwich, in regard to the age of the flint-implements associated, in undisturbed gravel, in the north of France, with the bones of elephants at Abbeville and Amiens. These were first noticed at Abbeville, and their true geological position assigned to them by M. Boucher de Perthes, in 1849, in his 'Antiquités Celtiques,' while those of Amiens were afterwards described in 1855, by the late Dr. Rigollet. For a clear statement of the facts, I may refer you to the abstract of Mr. Prestwich's memoir in the Proceedings of the Royal Society for 1859, and I have only to add that I have myself obtained abundance of flint-implements (some of which are laid upon the table) during a short visit to Amiens and Abbeville. Two of the worked-flints of Amiens were

discovered in the gravel-pits of St. Acheul, one at the depth of ten, and the other of seventeen feet below the surface, at the time of my visit; and M. Georges Pouchet, of Rouen, author of a work on the 'Races of Man,' who has since visited the spot, has extracted with his own hands one of these implements, as Messrs. Prestwich and Flower had done before him. The stratified gravel, in which these rudely-fashioned instruments are buried, resting immediately on the Chalk, belongs to the post-pliocene period, all the fresh-water and land-shells which accompany them being of existing species. The great number of the fossil instruments which have been likened to hatchets, spear-heads, and wedges, is truly wonderful. More than a thousand of them have already been met with in the last ten years, in the valley of the Somme, in an area fifteen miles in length. I infer that a tribe of savages, to whom the use of iron was unknown, made a long sojourn in this region; and I am reminded of a large Indian mound which I saw in St. Simond's Island in Georgia —a mound ten acres in area, and having an average height of five feet, chiefly composed of cast-away oyster-shells, throughout which arrow-heads, stone-axes, and Indian pottery are dispersed. If the neighboring river, the Alatamaha, or the sea, which is at hand, should invade, sweep away, and stratify the contents of this mound, it might produce a very analogous accumulation of human implements, unmixed, perhaps, with human bones. Although the accompanying shells are of living species, I believe the antiquity of the Abbeville and Amiens flint-instruments to be great indeed if compared to the times of history or tradition. I consider the gravel to be of fluviatile origin, but I could detect nothing in the structure of its several parts indicating cataclysmal action; nothing that might not be due to such river-floods as we have witnessed in Scotland during the last half century. It must have required a long period for the wearing down of the chalk which supplied the broken flints for the formation of so much gravel at various heights, sometimes one hundred feet above the present level of the Somme; for the deposition of fine sediment, including entire shells, both terrestrial and aquatic; and also for the denudation which the entire mass of stratified drift has undergone, portions having been swept away, so that what remains of it often terminates abruptly in old river-cliffs, besides being covered by a newer unstratified drift. To explain these changes I should infer considerable oscillations in the level of the land in that part of France—slow movements of upheaval and subsidence, deranging, but not wholly displacing, the course of the ancient rivers. Lastly, the disappearance of the elephant, rhinoceros, and other genera of quadrupeds now foreign to Europe, implies, in like manner, a vast lapse of ages separating the era in which the fossil implements were formed and that of the invasion of Gaul by the Romans. Among the problems of high theoretical interest which the recent progress of geology and natural history has brought

into notice, no one is more prominent, and at the same time more obscure, than that relating to the origin of species. On this difficult and mysterious subject a work will very shortly appear by Mr. Charles Darwin, the result of twenty years of observation and experiment in zoology, botany, and geology, by which he has been led to the conclusion that those powers of nature which gave rise to races and permanent varieties in animals and plants are the same as those which, in much longer periods, produce species, and, in a still longer series of ages, give rise to differences of generic rank. He appears to me to have succeeded, by his investigations and reasonings, to have thrown a flood of light on many classes of phenomena connected with the affinities, geographical distribution, and geological succession of organic beings, for which no other hypothesis has been able, or has even attempted to account. Among the communications sent into this section, I have received from Dr. Dawson, of Montreal, one confirming the discovery which he and I formerly announced, of a land-shell, or pupa, in the Coal-formation of Nova Scotia. When we contemplate the vast series of formations intervening between the tertiary and carboniferous strata, all destitute of air-breathing mollusca, at least of the terrestrial class, such a discovery affords an important illustration of the extreme defectiveness of our geological records. It has always appeared to me that the advocates of progressive development have too much overlooked the imperfection of these records, and that consequently a large part of the generalizations in which they have indulged in regard to the first appearance of the different classes of animals, especially of air-breathers, will have to be modified or abandoned. Nevertheless, that the doctrine of progressive development may contain in it the germs of a true theory, I am far from denying. The consideration of this question will come before you when the age of the white sandstone of Elgin is discussed—a rock hitherto referred to the Old Red, or Devonian formation, but now ascertained to contain several reptillian forms, of so high an organization as to raise a doubt in the minds of many geologists whether so old a place in the series can correctly be assigned to it."

Sir Roderick I. Murchison delivered a discourse "On the Geological Structure and Order of the Older Rocks in the Northern Counties of Scotland," in which he explained the progress which had been made in the classification of the rocks of sedimentary origin in Scotland. He alluded to the great leaders of Scottish geology, Hutton, Playfair, and Hall, and his immediate predecessors, Jameson, McCulloch, and others, and showed to how great an extent the chief point on which he was to insist—the metamorphism of sedimentary strata of various ages into crystalline rocks—had been ably illustrated by Hutton himself. After his day, however, mineralogy chiefly occupied the minds of geologists, and comparatively little progress was made for some years in geology as at present cultivated. With

William Smith, however, a new era arose in England, and the proofs which that sagacious man brought forward to show that each sedimentary formation was characterized by organic remains peculiar to it, and that there existed a regular order of superposition from the older to the younger strata, were the true foundations or keystones of modern geology. Sir Roderick then gave a very full account of his researches in the northern counties of Scotland, and concluded by calling the attention of the meeting to the progress which was being made by the Geological Survey of Great Britain under his direction, and under the special management in the field of his friend Professor Ramsay. Exhibiting certain sheets of maps, on the six-inch scale, of the counties of Edinburgh, Haddington, and Linlithgow, which explained the outcrop of the coal and limestone of these tracts, he trusted that the staff of geological surveyors at present allotted to Scotland would be soon augmented, and in that case he hoped to live to see the day, if maps were only provided, when all the geology of Aberdeenshire and the north of Scotland might really be worked out with accuracy. The present effort was chiefly confined to the application of recognized general principles of classification to the elucidation of the order of the older rocks of the Highlands; and nothing more could be attempted until the country possessed maps, the north of Scotland being almost the only country in Europe without an accurate map, a melancholy fact, on which he insisted a quarter of a century ago, when the Association met in Edinburgh in 1834. On that occasion the Association, at his request, memorialized the then Government; and this state of matters was being rapidly wiped away as regards all the tracts to the south of the Grampians; and he hoped that the skill and energy of his friend Colonel James and the officers under him would be so warmly supported by Parliament and the public, that Scotland would have before long a really good topographical map, without which no practically useful geological results could be worked out. Sir Roderick concluded his address by impressing upon the minds of those auditors who were not geologists the nature of the great difference between the formerly accepted notions of the order and equivalents of the older rocks of the north of Scotland, and those which he desired to establish by his reform, by pointing to two generalized diagrams. One of these, representing the old notions, exhibited a great central mass of rocks, termed gneiss, mica schist, quartz-rocks, with granites, porphyries, &c., flanked both on the east and the west coasts by Old Red conglomerates and sandstones. The other, on which he had previously lectured, exhibited the succession which had been evolved out of that which was previously an assemblage of crystalline rocks, distinguished only by their mineral characters, but undefined by their relative position and imbedded organic remains, and in which the rocks of the north-west coast were confused with those of the east coast.

Sir David Brewster, as Vice-president of the Royal Society of

Edinburgh, then presented the Brisbane Medal to Sir Roderick, who was addressed as follows by Mr. Robert Chambers:—

"Sir Roderick Murchison,—The Royal Society of Edinburgh, viewing your late researches in the Highlands of Sutherland with an interest and admiration shared by the whole scientific world, has thought proper to vote to you the first example of a gold medal, founded by its respected President, Sir Thomas S. Brisbane, for remarkable scientific services. In the paper read by you to the Geological Society in December last, the Society sees an admirable instance of laborious investigation in connection with a Scottish field. You have, sir, succeeded in putting into a new and correct place in the geological series, a band of formations which, from the days of McCulloch downwards, has attracted a large share of attention, both on account of its constituent materials and the magnificent scenery which it forms; and you have thus conferred a great favor upon your native country. It seems suitable that the Royal Society of Edinburgh, which heard the first speculations of Hutton and of Playfair, should take upon itself to stamp with the national approbation services so distinguished as yours. The Society, however, must not and cannot overlook the fact that your researches in Sutherlandshire only follow up a most remarkable series of geological investigations performed during the last thirty-five years, and which have placed you so high among the great chiefs of living British geologists. In succession, the mountains of Auvergne, the Alps, the Carpathian, the Urals, have owned your genius for research. You have recalled to the world the story of the first ages of life upon its surface. In the wide plains of Russia your diligence has been as conspicuously shown as in that Siluria which is all your own. Two superb and voluminous works and a hundred separate memoirs but faintly express the amount of your geological writings. Nor, on the present occasion, should your services, as the head of the Geological Survey, and as the frequent President of the Geographical Society, be forgotten. Neither should we fail to remember that remarkable triumph of science of which you are the instrument—the vaticination of an auriferous region in Australia from the observations you had made in the Ural Mountains. Viewing these many merits and your present active course, the Royal Society of Edinburgh cannot but feel proud in having the privilege of conferring upon you the first Brisbane prize; and it is their earnest wish and prayer that you may long be spared to enjoy the many deserved honors which a grateful country and an admiring band of fellow-laborers and a beneficent Sovereign have conferred upon you."

Sir Roderick Murchison replied in very feeling language, that no honor ever conferred upon him had touched him more than this testimonial at the hands of his own countrymen. He was gratified beyond measure at receiving this honor from a Society which, of all others in Europe, is most chary in conferring its honors, and has a

more limited number of honorary members. And all the more would it be esteemed that it was put into his hand by one of the most eminent of living philosophers..

The following is a list, so far as obtained, of the other papers read in the Geological section:—

Dr. Black, F.G.S., "On Coal at Ambisheg, in the Island of Bute."

Mr. W. H. Baily, F.G.S.. "On Sphenopteris Hookerii and Ichthyolites, from Kiltorkan Hill, Kilkenny."

Dr. Brice, "Notice of the Discovery of Upper Silurian Fossils in the Devonian Slates."

Dr. Anderson, of Newburgh, "On the Remains of Man in the Superficial Drifts."

Mr. Henry C. Hodge, "On the Origin of the Fossiliferous Caves of the Plymouth Limestone."

Mr. D. Page, F.G.S., gave in a report on the exploration of the Upper Silurians of Lesmahagoe, in terms of the Association's grant to Mr. Simon.

The Rev. Dr. Longmuir, "On the Restoration of the Pterichthys."

Mr. D. Page, Notice of some new Boreal forms of Mollusca from the Pleistocene deposits of Scotland.

Rev. W. S. Symonds, "On some Fishes and Tracks from the 'Passage-rocks,' and from the Lower Old Red Sandstone of Herefordshire."

Professor Daubeney, F.R.S., "On certain Volcanic Rocks in Italy, which appear to have been subjected to Metamorphic Action."

Dr. McGowan, "On certain Phenomena attendant on Volcanic Eruptions and Earthquakes in China and Japan."

Messrs. Garner and Molyneux, "On the Coal-fields of Staffordshire."

C. Moore, F.G.S, "On Brachiopoda, and on the development of the loop in Terebratella."

Dr. Buist, F.G.S., "On the Geology of Lower Egypt."

The President read a letter from Dr. Dawson, F.G.S., intimating certain discoveries which he had made of a land-shell and reptiles in the South Joggins Coal-field, Nova Scotia, and enclosing two specimens.

Professor Nicol, F.R.S.E., gave an able and interesting notice on the "Relations of the Gneiss, Red Sandstone, and Quartzite in the north-west Highlands," illustrated by various sections. Professor Nicol had visited the Highlands, and had arrived at a different conclusion as to the succession of certain crystalline and sub-crystalline rocks from that arrived at by Sir R. Murchison. He contended that the great series of rocks in question were of older date than that assigned to them by Sir R. Murchison, and endeavored to

prove, by a reference to the sections which he exhibited, that the order of superposition which he advocated was the correct one.

Professor Huxley read a paper on "Newly discovered Reptilian remains from the neighborhood of Elgin."

Rev. Professor Sedgwick, "On Faults in Cumberland and Lancashire."

Professor Rogers, "Some Observations on the Parallel Roads of Glenroy," in which he described the leading features of the district, and indicated as his opinion that the shelves or grooves on the surface of the hills had been formed by water in motion, and not by water at rest, as had been supposed.

Professor Harkness, "On Sections along the Southern Flanks of the Grampians."

Mr. J. Wyllie, "On some Old Red Sandstone Fossils."

Mr. C. W. Peach, "On New Fossil Fish from Caithness."

Mr. W. H. Baily, F.G.S., "On some Tertiary Fossils from India."

Adolphe Radiguel, C.E., "On a Fragment of Pottery found in a Superficial Deposit."

M. Gages, "On the Results Obtained by the Mecanico-chemical Examination of Rocks and Minerals." Instead of reducing them to powder, he simply broke them down and then submitted them to chemical tests. By this means some remarkable results have been obtained.

Mr. C. G. Thost, "On the Rocks and Minerals on the Property of the Marquis of Breadalbane."

Mr. Brady, "On some Elephant-remains at Ilford."

Mr. J. Miller, "On the Age of the Reptile sandstone of Morayshire."

Mr. D. Page, "On the Structure, Affinities, and Geological Range of the Eurypteridæ."

Professor Harkness, "On Yellow Sandstones of Elgin and Lossiemouth."

Rev. Dr. Longmuir, "On the Remains of the Cretaceous Formation in Aberdeenshire."

Mr. T. F. Jamieson, "On Drift-beds of the North of Scotland."

Mr. John Cleghorn, "On the Submerged Forests of Caithness."

Mr. Wm. Pengelly, F.G.S., "On the Ossiferous Fissures at Oreston."

Dr. G. D. Gibb, F.G.S., "On Canadian Caverns."

Mr. C. Moore, F.G.S., "On the supposed Wealden and other Beds near Elgin."

Rev. Dr. Anderson, "On the Dura-Den sandstone."

Mr. J. Miller, F.G.S., "On some New Fossils from the Old Red Sandstone of Caithness."

Mr. A. Geikie, F.G.S., "On the Chronology of the Trap-Rocks of Scotland."

Mr. H. C. Sorby, F.R.S., "On the Origin of Cone in Cone-structure."

Rev. H. Mitchell, "On New Fossils from the Lower Old Red Sandstone of Scotland."

T. F. Jamieson, Esq., "On the Junction of Granite with Stratified Rocks."

Professor Nicol, F.G.S., "On the Geology of Aberdeenshire."

Rev. Dr. J. Longmuir, "On Coast-section between Aberdeen and Dunnottar Castle."

Geological Survey of Missouri.—From the Fourth Report of Progress of the Geological Survey of Missouri, by Prof. G. C. Swallow, under date of December, 1858, we learn that more than half, and by far the most difficult part of the work, was accomplished. "The surveys of forty-four counties have been completed, seven are half done, nine have been commenced, and the preliminary surveys have been made in many others. The maps of twenty-nine counties have been carefully made out. Of these twelve have been engraved, and ten printed and colored, (7000 copies of each.) The reports upon fourteen counties have been made out, and a large amount of work done on the reports of other counties."

"In 1855 it was supposed that the Survey could be completed in six years, if the biennial appropriations were increased to $25,000. But it was found during the years 1855 and 1856, that the current expenses of the Survey were nearly doubled by the increased prices of horses, forage, provisions, and, in short, nearly all the articles used in the Survey; and that it would be difficult to get the work well done so soon. Still, in 1857 hopes were entertained that the work could be carried through in that time. But since the bad weather of the two past seasons, and the circumstances above named, have so retarded the progress of the work, there is no hope that it can be completed under four years, if the plan thus far pursued, of making accurate and minute surveys, and maps for each of the one hundred and eleven counties, be continued."

Minerals associated with Gold.—In the article by Dr. Genth, entitled, "*Observations on the Occurrence of Gold*," (p. 147 of this number,) the list of species found with gold, may be extended by the addition of the following extracts from a recent letter to the editor, from Dr. Genth:—

Mispickel occurs rarely at Union Mine in Union co., N. C., in Gaston county, and at Barringer's mine, with calcite and gold in Cabarrus co. "I have a pseudomorph of impure limonite evidently

after mispickel, with scorodite and tetrahedrite. I have also found mispickel in the ores which were taken to the Oriental mill, Nevada co., California. In addition to the mispickel, it contains galena, zinc blende, pyrites, and chalcopyrite. It is a very rich quartz ore, worth $175 per ton, but it seems that it could not be worked with profit!"

Geocronite occurs at Tinder's mine, Louisa co., Va.; Tetrahedrite (varieties) at Eldridge's mine, in Buckingham co., and in North Carolina, at Luderick's mine, and McMackin's mine (11 p. c. silver), in Cabarrus co., also at Briggs's (King's Mt.) gold mine. "I have lately received this mineral, in small particles, in ore from Grass Valley, California. Aikenite (Nadelerz) occurs at Col. White's mine, in Cabarrus co. Other interesting minerals, such as wolfram, scheelite, etc., have been observed at different localities."

The Editor has frequently observed the association of mispickel (arsenical iron pyrites) with gold, in the quartz veins of California, and the southern Atlantic States. Crystals of mispickel have been found in California, with filaments of gold extending through them.

IRON.

Shipments of Ore and Iron from Lake Superior.—A correspondent of the N. Y. *Times*, writing from Marquette under date of Oct. 11th, says:

"The season which is now closing has been one of great activity in the principal business of this portion of the Lake Superior region, the shipment of iron ore. The amount of ore shipped from the opening of navigation, thus far, is nearly three times that of the corresponding period last year. The following is a statement of the receipts of ore and iron, monthly, this season and last, by the Bay de Noquet and Marquette Railroad, on which the ore is brought from the mines, or rather quarries, which are 14 to 17 miles inland, to the lake for shipment.

	1858.	1859.
	Tons brought down.	Tons brought down.
May	2,773	8 261
June	5,564	13,637
July	8,943	16,653
Aug.	6,808	16,368
September	3,866	17,170
October, to 8th inst.	959	3,786
Totals	28,913	75,875

The three Iron Ore Companies, the Jackson, the Cleveland, and the Lake Superior, have had orders for ore in advance of their ability to supply it all the season; a fleet of from ten to twenty vessels has been constantly in port waiting for cargoes. The current price has been $3 per ton, of 2,240 lbs., delivered to vessels. The greater portion of this season's shipments has been to the blast furnaces located on the bituminous coal fields of Eastern Ohio and Western Pennsylvania. Several thousand tons have been shipped to the furnaces at and near Detroit, and one cargo has found its way Eastward as far as Danville, Penn. Lake Superior ore of shipping quality yields from 65 to 70 per cent. pig metal in the furnace, and about the same amount of metallic iron by analysis; it works to good advantage mixed with the leaner ores of Ohio and Pennsylvania, or it may perhaps still more profitably be worked alone. Several furnaces in the Mahoning Valley, and on the line of the Erie and Beaver Canal, are now using this ore exclusively with very favorable results. Its cost at the furnace is from $6 to $7 the ton, and the manufacture of iron from it is more profitable than from the neighboring ores, which yield but 20 to 30 per cent., and cost $1 to $1 50 the ton. It is, perhaps, not too much to say that the introduction of Lake Superior ore has redeemed the business of making pig-iron throughout a considerble portion of the bituminous coal region of Eastern Ohio and Western Pennsylvania, from the situation of a difficult and uncertain enterprise, and has placed it on a footing of sure prosperity. It has made its way steadily and surely, in spite of natural prejudice and all the disadvantages of inexperience in its use, and wherever it has gone has made new friends and customers. Next year not less than forty furnaces will use it, wholly or in part, to supply which will require between 150,000 and 200,000 tons. The iron-ore companies are making preparations to supply a largely increased demand next season—to do which it is only necessary to uncover surface and enlarge openings at the mines so as to enable a larger number of men to be employed to advantage. The Railroads will also be prepared with increased facilities for transportation of the ore.

The charcoal furnaces near this place are in full blast. The Pioneer Company's furnace at Negaunee, near the Jackson Mine, is turning out upwards of twenty tons of excellent iron per day with two stacks. The Meigs Furnace, at Dead River, makes ten tons a day with one stack. The iron of both these Companies' manufacture is in high repute, and meets a ready sale, at remunerative prices.

The Scotch Iron Trade.—During the quarter closing with September last an especial activity is reported at Glasgow on continental account, caused in part by the peace, and in part by a slight reduction of the duty on importation into Russia. The shipments and local consumption for the quarter were 245,000 tons, an increase of 30,000 tons over the same quarter of 1858, and of 37,000 tons over 1857. For the first time in two years, also, there is a reduction of stocks of

any note, the deliveries being 15,000 tons over the receipts, and the total of stocks in hand at furnaces and stores now standing at 315,-000 tons. Prices are, however, still reported as lower than last year by some three or four shillings per ton, and lower than in 1857 by eighteen shillings sterling, or four to four and a half dollars per ton.

The point of interest to us is that, with a standard production of Scotch pig-iron, the prices were very low until a special continental demand sprung up in consequence of the peace, our own position in that market having remained quite stationary for the past year. Scotch iron is still very low, as compared with 1857, and more than four dollars per ton of the protection we then enjoyed is removed by the fortune of commercial changes since that time.—*Phil. N. American*, Oct. 24.

COPPER.

Lake Superior Mines.—We extract the following intelligence from the Portage Lake Mining Gazette:

"HANCOCK.—Four metal-bearing belts have been discovered on the location of this organization. Their position can be defined by reference to the conglomerate formations running parallel with these. At a distance of nearly 1000 feet west of the Pewabic course, in a conglomerate deposit, and 450 feet further west is still another. Between these, two of the lodes (those upon which they are at present working) are situated. The first vein is 60 feet from the east conglomerate, and the second about 100 feet from the west. Overlying the western conglomerate belt, and below the trap, is the third of these cupriferous deposits, and at a distance of about 300 feet to the west of this is the fourth.

"On the two between the conglomerates, a force of twenty-eight men are at present engaged. The show is most wonderful, and so very much so, that their tram-road, from the mine to the lake shore, is rapidly approaching completion, and this, while the workings are in their infancy. Mr. Ralston, well known among us, as the reliable and energetic contractor for the Quincy train, also has charge of this work.

"Three shafts are at present being holed. The No. 1 on the western side of the two belts between the conglomerate, has attained a depth of 60 feet, and the No. 2 on the same deposit has been sunk 15 feet in the rock. On the east vein the No. 1 shaft has attained a depth of 76 feet. The adit is being driven into the No. 1 shaft, which will be some 375 feet in length—about 200 feet of this

distance being through the rock. The character of these deposits are sufficiently peculiar, being less "vugy" (to use the miner's expression) and more compact than the Pewabic deposit.

"QUINCY.—Some glorious results have recently been obtained from the explorations on the Pewabic lode on this location. At the point where the Quincy (true) vein cuts the above deposit, there has been a heave of this last of some two hundred feet to the east, thus altering its absolute, while its relative position to the east conglomerate belt, being some 465 feet distant, remains the same. In opening this, by exploring trenches, about one ton of mass copper was taken out in an interval of time of very little over a week, and with a working force of about five men. It is certainly a most promising show. The belt at that place has a width of over fourteen feet with quite well-defined walls, agreeing with the Pewabic.

"On the line of this deposit the new adit level is to be driven. This will cut the old workings at about the 80 fms. level, and its economical bearings cannot be too highly estimated. A tramroad, it is the intention of the superintendent, is to be laid in the adit level.

"PORTAGE MINE.—Whilst on the other side the search for the Pewabic lode is the great point on which the activity is centred, operations have not been less energetically pushed forward on the south side of the lake. On the Portage location the Isle Royal lode has been opened at several points, by cross trenches, and has proved, so far, wonderfully rich. The copper bearing belt runs parallel with the old Portage belt, which was formerly extensively worked, an adit having been driven on it over 1000 feet in length. The Isle Royal vein is distant some 250 feet to the east of the Portage. At the time of the suspension of operations in 1857, two shafts, 35 and 40 feet deep, were sunk. At a distance of 363 feet northwards of the northernmost of these two shafts, the vein shows up well. Four hundred and forty-three feet north of this last, the lode has a width of ten feet, and from the superficial openings made three tons of copper were taken out. One hundred and thirty feet further north the belt is 12 feet in width, and from the cutting there about two tons of copper were taken out. At a distance of 46 feet to the west of this last point, a small lode was opened by means of two shafts; this was formerly supposed to be the Isle Royal vein, but their recent discoveries showing up a belt with the same situation, strike and character of vein and wall rock, settle the matter completely. The vast amount of copper which this deposit exhibits in the new openings, appears to be principally concentrated near the hanging wall, although the foot wall can by no means be considered as poor. The proprietors of this location are to be congratulated upon the happy results of their explorations; and we may hope that though our town has progressed with rapid strides the past year, the opening of spring will witness a still more gigantic, yet still healthy

growth. Mining discoveries on both sides are sufficient indications.

"Isle Royal.—The product of this mine for the month of September, is as follows:

Mass,	2,236 lbs.
Barrel,	25,720 "
Stamp work,	14,582 "
Total,	42,538 "

Or 21 tons 538 pounds. Only 16 heads of the old Cornish stamp were run during that month.

"Pewabic.—The monthly product of this mine still continues up in the "big figures." The following is the yield for September:

Mass,	9,176 lbs.
Kiln Copper,	52,615 "
No. 1, stamp work,	24,000 "
No. 2, "	41,804 "
No. 3, "	1,069 "
Total,	129,564 "

Or 64 tons 1,564 pounds.

"Franklin.—The Franklin yielded beyond its former product. The amount of copper taken out during the month of September, was 51 tons.

"Toltec.—Explorations on the lands of the Toltec Mining Company, have led to the discovery of a vein which is believed to be identical with the Minnesota North Lode. The character of the vein stuff and rocks, together with its position with reference to the conglomerate belt, is such as to warrant this belief. The openings were not sufficiently advanced to tell much in regard to its value, but so far the show has been most encouraging, and should certainly be an incentive to further operations.

"Smelting Works.—The extraordinary cheapness of coal, brought in many cases as ballast, has led to the establishment of smelting works at the Bruce mines, which will have a great effect on mining there. In the early days a smelting house was erected, but soon abandoned, because it was cheaper then to carry the dressed ore to England than to bring the coal to the ore. All that is changed, and a firm have commenced smelting in the old works. They will use up ores which have hitherto been cast aside as not worth exporting, and their works will open a new era in mining. The expensive machinery hitherto used will be no longer required, as hand-dressing will suffice to bring the ore into the proper state for smelting."—*Min. Gazette*, Sept. 3d.

GOLD AND SILVER.

Rocky Mountain Gold Mines.—The correspondent of the Missouri Republican at Gregory Diggings, Oct. 1st, writes:—

It was generally contended during the summer months that the mining season would not by any means be made to extend beyond the day on which I write. Four months was all that even men who had spent many years at the base of these mountains were willing to grant as the period during which mining could be possibly carried on. But five months have already elapsed since Gregory and his intrepid companions invaded this valley, and nobody thinks as yet of abandoning the search for gold and beat an involuntary retreat before the stern, resistless antagonism of winter. It is true that for some time the thermometer has been in the habit of falling every night to and even below the freezing point. Seams of ice have further been visible every morning on the banks of the brook that winds its rapid course through this valley. But the days have been clear and sunny for the last three weeks, with but one or two exceptions, and from the moment the warm rays of the sun commence vibrating through the many valleys and gulches of this mining district, the temperature of the air generally experiences a sudden rise and enables miners to carry on sluicing and digging throughout the day without any great discomfort. It is true that the water has an icy coldness, but most miners have improved their mining apparatus so as to enable them to pursue their business without coming in immediate contact with this disagreeable element.

How numerous the host that penetrated this part of the mountains during the summer just closed has been, becomes evident from the thousands that yet remain, in spite of the steady efflux that has taken place for the last ten weeks. Dr. C. A. Roberts, the Recorder for the Gregory district, and Editor, *pro. tem.*, of the *Gold Reporter*, has of late undertaken the laborious task of ascertaining the number of miners at work during the last week of September in the various diggings in this vicinity, and the respective yields of the claims worked by the several companies. The figures he collected, and the aggregate of which I subjoin further below, can be considered as representing an exact reflection of truth. The Doctor—a native of Jefferson county, Missouri, but more recently a resident of Pekin, Illinois—is a highly educated, accomplished, and conscientious gentleman, and entered upon the labors of gathering statistics with the determination of making them accurate as possible. According to his report, there were on the 24th ult., eleven hundred and four men at work in four of the main gulches, viz.: Russell's, Nevada, Illinois, and Missouri flats. The bulk of this number, 891, was engag-

ed in Russell's gulch. The balance is almost equally divided between the remaining three. The aggregate amount of gold taken out by the 1104 miners represented a weekly average value of $44,259.

The mining population of the Gregory gulch proper, is estimated at about three hundred. In the Lake, Iowa, Leavenworth, Patch and other adjoining diggings, there are altogether over eight hundred people at work; so that we have an aggregate number of nearly two thousand three hundred individuals, for an area of about six square miles.

A ride over the mining grounds, outside of Gregory's, revealed to me the fact that quartz mining is not confined to the latter locality, although "gulch digging" is the prevailing characteristic in most of the other gulches. In Russell's and the Nevada and Iowa gulches, leads containing pay-dirt have been opened, and are actively worked. In the Iowa diggings, Messrs. Sheffaer, Cooper & McLain and Cobb & Co. have averaged nearly 100 dwt. per day for the last month or so, although they work but one sluice and from three to five hands.

I am inclined to the conviction that the Nevada gulch will prove to abound as much in gold-bearing quartz as the Gregory gulch. But few of the Nevada leads contain, however, crevices filled with pay-dirt, as it was the case with most of the Gregory veins in the early part of the summer. They generally consist of *solid* quartz exclusively, and hence their riches will be developed with the introduction of machinery only. There is also a low mountain of almost pure quartz in the Nevada gulch, that has been denominated the "Gold Hill" by the miners. In whatever spot its quartz has been tested, it was uniformly found to be exceedingly rich, yielding, as your townsman, Dr. Willing, contends, 5 cts'. worth of flour gold to the ounce of rock. A. W. Forney, from Putnam county, Ind., took out a nugget of almost solid gold in the course of last week, that weighed nearly 102 dwts.

Quite a number of miners have determined to brave the rigor of the winter in the Gregory and adjacent diggings. Most of them will be engaged in tunnelling—a kind of work which they expect to be able to carry on in spite of the severest possible frosts. The tunnels are to be dug for the purpose of more easily reaching the subterranean layers of gold-bearing quartz. Some of them are to be hundreds of yards long.

The steam quartz mill of Messrs. Conklin & Co. has already made a few experimental runs, the results of which afford, however, no definite basis on which to rest calculations as to the true richness of the Gregory quartz.

The number of simple grinders and crushers for reducing the quartz to powder is now ten. Most of them are awkward structures, that are likely to be used only as long as nothing better can be had.

They are worked with both water and ox-power. The capacity of those operated with water is about sixty bushels per day. In consequence of the imperfection of the working process, but two dollars' worth of gold is obtained per bushel. The capacity of the ox-grinders does not exceed two to three tons per day, from which $25 worth of gold is secured on an average.

The Rocky Mountain Reporter and *News* bring mining news to the 27th Sept. *The Reporter* gives a statistical report of the several gulch mines near Gregory's, which is prefaced as follows:

We present this week a full report of three of the gulches in this region. From the head of Russell Gulch to where G. Russell & Co. are at work, there are 60 companies and 300 men at work, who are taking out on an average $10,500 a week. From there down, and the same in the Nevada and Illinois gulches, we give the name of each company, the number of hands at work, and the amount taken out weekly by each company. The season is so far advanced that hundreds have recorded their claims, and gone home to make preparations for next year's work.

We find in Russell's Gulch 891 men at work; they are taking out on an average weekly $35,585, or nearly $39 per man.

In Nevada there are 97 men at work, who are taking out weekly $3,750, or nearly $30 per man.

In Illinois Gulch, Missouri Flats, there are at work 116 men, who are taking out weekly $4,920, or over $42 per man.

Of the quartz leads, *The News* has the following:

"We are informed by our friend Gov. Russell, that Mr. Coleman, of the firm of Geo. LeFevre & Co., has just returned from the mountains, having been engaged for some weeks in thoroughly prospecting and testing the extent and wealth of the different quartz leads. Mr. C. is an old Californian, and was there engaged in quartz crushing. He states that the quartz is at least twice as rich as in California, and it is his belief, from actual personal tests, that three cents to the pound is a fair average, while the number and extent of the leads can scarcely be calculated, the whole region of mountains for miles above and below Bowlder being marked and seamed with them at short intervals."

A correspondent of the *Leavenworth Times* gives an account of a ditch for furnishing water for gold mining to the Russell and Gregory diggings, at the Rocky Mountains, now in course of construction, at a cost of $23,000, which will be from twenty-five to thirty miles in length, three feet wide at the bottom, two feet deep, with a velocity of water four miles per hour.

Carson Valley and Walker's River Mines.—Late accounts from Carson Valley and Walker River mines continue to excite great attention. A stampede of Californians in that direction has already commenced, and promises to equal the emigration to Frazer River. These mines are on the east side of the Sierra Nevada, and are supposed to extend from Honey Lake on the north to Walker's River on the south—a distance of two hundred miles. The principal discovery yet announced is called Gold Hill. It is a mound sixty feet high, five thousand long and two thousand wide, and lies twenty miles north of Carson Valley. It is traversed by veins of auriferous quartz, a part of which, when decomposed, realized from $500 to $2,500 per ton.

Large quantities of silver ore continued to arrive from Carson valley at San Francisco for shipment to Europe. Emigration in the spring will probably result in the complete exploration of the whole co ıntry east of the Sierra Nevada, and the discovery of equally rich mines to any in California.

BOOKS AND REPORTS RECEIVED.

The Manufacture of Photogenic or Hydro-carbon Oils from Coal and other Bituminous Substances, capable of supplying burning fluids. By Thomas Antisell, M. D. 8vo. pp. 144. New York. D. Appleton & Co., 1859.

History and Documentary Evidence, relating to the property of the Consolidated Franklinite Company. Large 8vo. pp. 50. New York, 1859.

Manual of Public Libraries, Institutions, and Societies in the United States and British Provinces of North America. By William Q. Rhees, chief clerk of the Smithsonian Institution. 8vo. pp. 687. Philadelphia. J. B. Lippincott & Co., 1859.

This is not a work of dry statistical details, but contains historical and descriptive notices of all the important Libraries and Literary Institutions in the United States. The grand aggregate number of libraries now is 50,890, with 12,720,686 volumes. In all this list we are sorry not to find mention of a library of an American school of mines—an absence for which we trust there will be no reason in the next issue of this or a similar work.

Map of the town of Plymouth, Windsor co., Vt., colored geologically, by Albert D. Hager, 1859.

THE

MINING MAGAZINE

AND JOURNAL OF

GEOLOGY,

MINERALOGY, METALLURGY, CHEMISTRY, AND THE ARTS IN THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

JANUARY, 1860.

ART. I.—THE LEAD DEPOSITS OF THE MISSISSIPPI VALLEY.*— BY PROF. J. D. WHITNEY.

[*Extracted from the Report on the Geological Survey of the State of Iowa. Vol. I.*]

THE simplest form in which lead ore is found occurring in the region under consideration, is the vertical sheet, or upright crevice filled with galena, where the whole remains in the same condition in which it was when the ore was first deposited in the fissure, the rock not having undergone decomposition, so as to allow the mineral to be washed out of its place. The thickness of these sheets varies from that of a knife blade up to several inches: in very rare cases, a solid sheet of ore may extend for some distance, having a thickness of a foot or more; but bodies of ore of this magnitude are usually connected with "openings," as will be explained farther on, or they have a nearly horizontal posisition, and belong to the class of "flat-sheet deposits." The vertical sheet is usually from one to three inches in thickness, and is pretty regular in its form, the walls maintaining

*Continued from page 102, No. 2, Vol. I., second series.

their parallelism for some distance and then gradually closing up, the ore thinning out and disappearing. In these crevices there are rarely any of the usual accompaniments of a vein, such as a gangue or vein-stone, and never smoothed and striated walls: there is sometimes a little clay, or ferruginous matter between the ore and rock; but, more generally, the one is directly adherent to the other without any separating substance. When the crevice is barren of ore, it is usually filled with clay, or, more rarely, with brown oxide of iron. Sometimes when the ore gives out, calcareous spar takes its place, especially in the lower part of the Galena limestone; but neither does this mineral, or any other vein-stone, ever appear in the vertical crevices with the comby structure characteristic of the true vein.

Vertical sheets of the kind just described are rarely of great extent in any direction; but a number of them are sometimes grouped together, so that they may be profitably mined in one excavation. Single sheets are said to have been followed down uninterruptedly for nearly one hundred feet, but no such instances have ever fallen under our observation. On the whole, but a small portion of the ore raised occurs in the vertical sheet form; in much the larger number of instances, the vertical crevice is connected with what is called an *opening*, and this may be considered as the characteristic mode of occurrence of the lead ore in the middle and upper portions of the Galena limestone, the flat sheet being almost exclusively limited to the lower part of that rock and the upper portion of the Trenton.

The *opening* is the expansion of the crevice in a single stratum or a set of strata, in which the conditions were more favorable to the accumulation of ore, and, on passing into which, the previously nearly closed fissure widens out suddenly and becomes productive. This change from a mere seam to a wide opening is the more marked, because, in the metalliferous stratum, the rock adjacent to the crevice has usually undergone decomposition, and been partially or entirely removed, leaving a cavity of irregular dimensions, which sometimes expands out into what may, with propriety, be called a cave. To this peculiarity the term *opening* owes its derivation.

In different localities, the forms and dimensions of the openings vary considerably. Their vertical height is not usually less than four, or more than fifteen feet; and the same

opening may vary between these limits, in different parts of the course. The opening is equally liable to expansions and contractions in width; and, while from four to ten feet may be considered as being the usual dimensions, there are localities where the rock retains its metalliferous character, and is more or less marked with the peculiarities of the opening, for a width of forty feet. The number of openings, or productive strata, which may in any one locality be found occurring, one below the other, is variable in different districts of the mining region. In the majority of cases, there is only one; and, although there may be as many as five, one is usually much more productive than the others.

The transition from the unproductive into the metalliferous stratum is usually a sudden one, so that the rock above the opening is firm and solid, and covers it like a cap, and is for this reason called, by the miners, the *cap-rock*. Not unfrequently, however, the expansion takes place more gradually, and often, in the same crevice, unequally, so that the opening will in one place be capped over by a flat stratum, in which nothing more than a mere seam is discernible; while, in other places, the cavity will extend far up into the cap-rock, gradually diminishing in width as it is followed upwards. When the opening presents itself with irregular forms, and with a solid cap above, it is called a square-opening: when it becomes irregularly elliptical in form and expands to a great size, it comes under the denomination of a cave-opening. Some openings exhibit irregularly-formed conical cavities passing up into the cap-rock, which are called chimneys, and which are often lined with a stalactitic deposition of carbonate of lime. The annexed wood-cut, figure 44, will serve to convey an idea of these singular forms, which have, apparently, been worn out by the percolation of water. This particular instance of the occurrence of chimneys was observed at Schaffner's diggings, near Dubuque, where a cave-like crevice filled with clay, but barren of mineral, was opened for some five hundred feet in length. The opening itself was from six to eight feet in height, and about the same

Fig. 44.—Opening with chimneys, near Dubuque.

in width; but numerous chimneys were observed extending up into the cap-rock, sometimes to a distance of twenty-five or thirty feet: many of these were beautifully rounded, and tapered upwards to a fine point, being lined with incrustations of calcareous spar, and, in some cases, with this mineral in layers alternating with clay.

The manner in which the ore is disposed in the openings is very simple. More generally, the opening is only partly filled, and the materials which occupy it are of such a nature as to show that they have been derived from the decomposition of the rock which once occupied the opening, and through which galena was disseminated in various forms, such as nodules, strings, bunches, and flat-sheets. Often, the arrangement of the material in the opening is such that it may be observed to have undergone decomposition without having been removed from its place; as the stratification may be traced distinctly across the decomposed mass, from one side of the crevice into the other. Again, in other cases, the whole, or the larger part of the contents of the opening, have been washed out by currents of water; leaving an irregular cavity, at the bottom of which a mass of detritus is accumulated, and which will be found filled with fragments of ore, if the opening was a rich one. Sometimes, after the contents of the opening had been removed, it has become filled up again with clay, which has slowly filtered into it from above, through crevices communicating with the surface. This clay has, in numerous instances, been found to contain the remains of a former generation of animals, once the inhabitants of this region, among which the peccary, mastodon, wolf, and buffalo have been observed; the two former species in so many localities, as to lead to the inference that they were once abundantly distributed through the valley of the Upper Mississippi.

In some instances, the opening seems to have been formed previous to the introduction of mineral matter into it; although, more usually, it appears to have depended for its existence on the change which took place in the character of the rock, at the time of the deposition of the ore. This change, however, was not always necessarily connected with the presence of lead ore; as there are cavities resembling, in most respects, the mineral-openings, and yet entirely barren of mineral. Such cavities have also been formed, and ore

has been afterwards introduced into them, either depositing itself on their walls, and lining them like a shell, or filtering in from above and forming a crystallized mass, hanging down into the vacant space below; instances of these forms will be described, in noticing particularly some of the more interesting mines near Dubuque, farther on in this chapter.

FLAT SHEETS. The deposits in the form of horizontal sheets, or in flat openings, are mostly limited to the lower part of the Galena limestone, and the upper and middle portion of the Trenton: where horizontal layers of ore occur in the upper portion of the Galena, it is chiefly as subordinate to the vertical crevices; the latter sending off branches or lateral offshoots, of moderate dimensions compared with the principal vertical mass. This arrangement of a vertical crevice, with flat sheets subordinate to it, is intimately connected with the form of the openings themselves; since it is by the decomposition of the rock surrounding the deposits of lead, that the dimensions of the cavities have been determined.

The deposits in flat sheets are quite various in form; but, in the greater number of instances, they are imbedded in, or interstratified with, the solid rock, the strata with which the ore is associated not having undergone decomposition, so as to give rise to a cavity. Much more frequently than in the vertical crevices, the galena is found associated with other metalliferous ores, especially with blende and pyrites; while the presence of such mineral substances as are of common occurrence in other mining regions, as vein-stones, is almost exclusively confined to the flat-sheet deposits. The mineral most frequently found in this connection is calcareous spar, or *tiff*, as it is usually called by the miners; and heavy spar is not uncommon, but crystallized quartz is almost unknown. In some instances the larger portion of the metalliferous layer is made up of the sulphurets of zinc and iron, the galena appearing to be quite subordinate in importance to these substances. The different ores and minerals associated together in the flat-sheet deposits not unfrequently assume something of the arrangement which they would be likely to have in regular veins: for instance, at Mineral Point, a deposit of blende and pyrites about eighteen inches thick was noticed, in the centre of which were large cavities lined with crystallized galena. More frequently, the galena occupies the lower side

of the metalliferous layer, the other ores lying above it in alternating layers, as shown in the annexed wood-cut (Fig. 45), which represents a section of a portion of the mineral deposit at the "Marsden lode" near Galena; the thickness of which, at the point represented, was about twelve inches. In this case there was a shallow cavity beneath the ore, partially filled up with detritus and fragments of ore; but usually, throughout the mine, the ore was solidly imbedded in the rock. In the flat openings, the galena may also occur without any trace of gangue associated with it; the pure ore being attached to the solid rock in a thin sheet, or in irregular bunches of crystals. The annexed figure (Fig. 46) represents an opening of this description observed at Shullsburg, in which the galena, represented by oblique lines of shading, may be seen to be adherent to the cap rock, the bottom of the opening being covered with decomposed rock and fragments of ore which have fallen from above. In other instances, at the same locality, the opening had an almost spherical form, heavy bunches and plates of ore lining its interior like the crystals of an immense geode.

Fig. 45.—Section of Marsden lode.

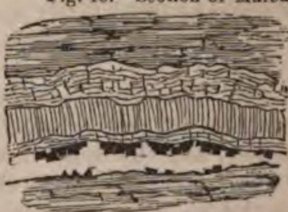
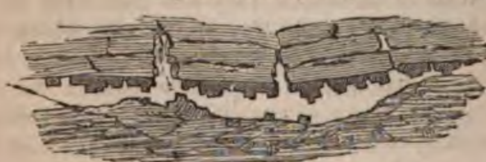


Fig. 46.—Flat opening at Shullsburg.



The general shape of these flat-sheet deposits is very irregular; but in many instances they are rudely circular in their outline, the deposit gradually thinning out in all directions from the centre. At the "Marsden lode," for instance, the metalliferous mass has something like the form represented in the annexed section (Fig. 47); the sheets of ore descending, by steps, from the interior towards the limits of the mass in each direction, and the diameter of the whole being about one hundred feet. On the summit of the

Fig. 47.—Section of Marsden lode.

dome-shaped mass, galena was the predominating ore; but the quantity of blende and pyrites appears to increase considerably as the mass descends.

The most remarkable instance of this form of deposit observed by us, and probably one of the largest accumulations of ore ever met with in this region, was at "Mills's lode," near Hazle Green, which, when examined in 1857, presented the following appearances. A mass of ore was exhibited in the workings, of a saddle shape from east to west; the flat part above being twenty feet across, and varying from two to three and a half feet in thickness of solid galena, which was separated from the rock by thin selvages of a decomposed ferruginous substance: in each direction, as observed in the east and west cross section, this mass falls off at a steep angle, varying from 30° to 45°; and it had been worked on one side to the depth of twenty, and on the other, fifteen feet, the ore slightly diminishing in thickness in its descent, but still exceeding one foot on each side. In a north and south direction, the mass had been removed for a length of a hundred and twenty-five feet, the last forty feet rising gradually towards the surface. Thus it will be seen that a face of nearly one hundred square feet of solid ore was exposed in one section of the workings, presenting a truly interesting spectacle;—one of the great prizes which are occasionally drawn in the lead-mining lottery. About twelve hundred thousand lbs. of galena had been taken out from this place previous to May 1857, and there could be no doubt that several millions more remained to be removed, at an almost nominal expense, the deposit being near the surface and entirely free from water.

We have thus briefly sketched some of the most important forms of occurrence of ore in the lead region; but to give the minute details of all the variations which have been observed would be quite impossible, for want of room. We must therefore be contented with a somewhat particular description of the principal workings which have been accessible in the vicinity of Dubuque, within the last four or five years, and which we have had an opportunity of examining.

The surface occupied by the Galena limestone on the Iowa side of the Mississippi, is but small in extent compared with its area in Wisconsin; and the profitable workings have been chiefly carried on in the immediate vicinity of Dubuque, a large part of the district occupied by the lead-bearing rock in Iowa not having as yet been found to contain any productive crevices.

Beginning at the south-east and proceeding north-westwardly, we first notice the diggings in the valley of the Tête des Morts, along which stream the Galena limestone is exposed in low cliffs for some distance. So far as we could ascertain, these diggings have never been very productive; and as they are now entirely abandoned, we have no definite information concerning them.

The mines in the vicinity of Dubuque come next in order. These occur over most of the space extending from Catfish creek, in a north-westerly direction, as far as the middle fork of the Little Makoqueta, occupying a belt from three to four miles wide to the west of the Mississippi. The Hudson river shales cover the elevated surface over a considerable portion of this area; but as the streams have cut down into the Galena limestone, the crevices are first discovered by their outcrop in the valleys, and then worked, frequently, by shafts sunk through a considerable thickness of detritus and shale before reaching the lead-bearing rock. (Compare the geological map and the diagram of the lead-bearing crevices in the vicinity of Dubuque, accompanying this Report.)

The mines in the vicinity of Dubuque are among the most interesting and remarkable of the whole lead region. Extending over an area on the surface of hardly more than twelve to fifteen square miles, there is probably no district of equal extent in the Mississippi valley, which has produced so large an amount of ore. The crevices are more extensive, both vertically and longitudinally, than in any we have observed in Wisconsin; and their whole arrangement and grouping exhibits a degree of regularity which is rarely exhibited by this class of mineral deposits, and which most closely assimilates them, in this respect, to true veins.

The characteristic form of occurrence in the Dubuque district is the vertical crevice with openings, which frequently expand into large caves several hundred feet in length, and from which, not unfrequently, several millions of pounds of mineral have been taken.

A somewhat particular description of the mines which have been accessible during the past four or five years, in the vicinity of Dubuque, will serve to illustrate the character of the deposits on the west side of the Mississippi. In general, during the time since our personal acquaintance with this portion of the lead region commenced, there have not been, at any one time, more than one or two important localities where working was carried on, and where any considerable amount of lead was raised. In 1852, Levin's lode was yielding very large amounts ; this was mostly worked out during that year and 1854. In 1853 and 1854, Stuart and Bartlett's lode was producing extensively. In 1855, there does not appear to have been any one mine at work which was yielding a large amount of ore. In 1856, Kennedy's was the most important lode worked. In 1857, Kerrick & Jones had erected a steam engine and were taking out large quantities of ore from their mine, which had been for some time lying dormant on account of the water. These are the principal mines which have been accessible to us since the commencement of the Survey, and they have together furnished a large portion of the lead which has been raised since 1852.

STEWART AND BARTLETT'S LODE. This very interesting locality was still partially open for examination in 1854 and '5, although most of the lead had been taking out. Some of the appearances observed here are peculiar, and throw some light on the mode of decomposition of the ore, as well as on the action by which the crevices have been formed.

A space was worked out, open to day, at one end of which a good exhibition was afforded of the mode of occurrence of the ore at this locality, and of the manner in which the strata had been impregnated with it, through the limited space called the opening ; the rock remaining, in this part of the mine, nearly in its original position, not having been washed away. The wood-cut, Fig. 48, on the following page, represents the general appearance of the rock at this point. The width of the opening, between the walls, is about fifteen feet, and its vertical height not far from thirty-five feet. Within this space, it will be seen, that the strata are slightly bent downwards and broken in numerous places, leaving cavities between the fractured edges of the strata in which a portion of the ore has been deposited, as represented by the patches of

oblique shading. The larger part of it, however, is collected along the walls of the opening, especially on the north side, where the rock is broken up into small pieces and somewhat decomposed, forming with the ore a brecciated ferruginous

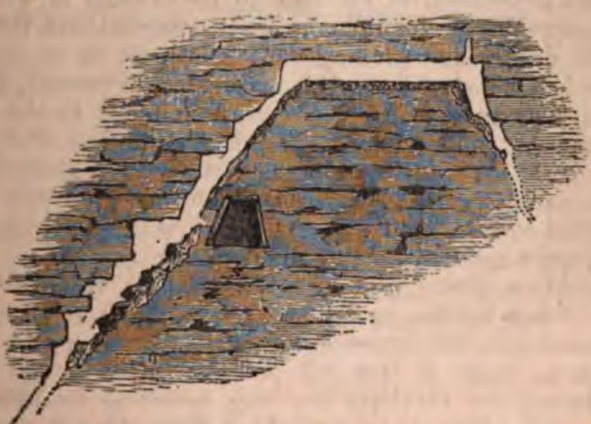
Fig. 48.—Section of opening at Stewart and Bartlett's mine.

mass. The decomposition of the rock had evidently not proceeded quite as far in this case as in some others, or we should have had, instead of the mass of fractured strata still in place, a cave limited by the walls of the opening on each side and filled partially with detritus, clay, and "tumbling rock," with fragments of galena scattered through it.

The workings at this locality have been on two different

levels, in an irregular crevice, or two crevices connected together by flat openings. The excavations on the upper level follow an irregular crevice for several hundred feet, which had been entirely worked out before being examined by us, and which is said to have produced but little mineral. The lower drift is forty-two feet below the level of the upper, and was extended a little over two hundred and seventy feet to the west of the shaft, and a considerable distance in the other direction, but how far, was not ascertained, as it had become filled up in that direction; probably over eight hundred feet. This lower drift runs in a crevice of varying width and height, sometimes widening out to twelve or fifteen feet, in other places closing within a few inches, and chiefly filled with clay and decomposed rock with fragments of ore. At the extremity of this drift the crevice comes to an abrupt termination, in a cavity such as would have been produced by the sinking down of a portion of the rock shaped something like a flat-bottomed boat, as represented in the annexed wood-cut, figure 49, in which the part left white indicates the vacant space, the flat upper part of which is fourteen feet wide and two and a half

Fig. 49.—Section at west end of Stewart and Bartlett's lode.



feet high, while the crevice runs off on each side at a steep angle, to an unknown depth. At the upper right-hand corner, the crevice is seen continued upwards in the cap rock; this probably connects with the crevice worked in the upper drift as noticed before, and which was somewhat to the north of the

lower one. The section is an interesting one, as showing how the formation of the crevice, in this portion of it at least, was due to a mechanical cause originating within and confined to a limited space in the rock.

We were informed that four millions of pounds of mineral had been taken from these excavations, which, when visited by us last year, seemed to have been entirely abandoned, and were rapidly filling up again with clay and sand.

LEVIN'S CAVE. For a description of this very interesting locality, as it appeared when first discovered, we are indebted to C. Whittlesey, who visited it immediately after its discovery by Mr. Levins, and before it had been at all disturbed. This was in October, 1850 ; it was first visited by one of us two years later, after about two million pounds of ore had been removed from it. The locality, as at first seen by Mr. Whittlesey, presented a narrow cave or crevice entering from the side of a hill, and capable of admitting, although in some places with great difficulty, the passage of a man ; the crevice had a nearly east and west direction in general, with many small deflections from a straight course. We annex Mr. Whittlesey's description of his visit to the locality in question. After speaking of the difficulty of squeezing between the walls of the narrow and winding crevice, he goes on as follows : " We had not gone far in this uncomfortable manner, when a handsome cave appeared before us, illuminated by the lights in front. It was a square room, with a mud floor and a rock ceiling, along the middle of which was a seam or vertical crevice, containing galena. This crevice was about two feet broad, the sides covered with mineral six to eight inches thick, leaving a space between the inner faces of the mineral, up which we could see several feet. There was about this crevice an entirely new feature, so far as I know. The solid mineral projected from this crevice downward, a foot to a foot and a half in a 'sheet,' as they call it, eight to ten inches thick, and twenty-five to thirty feet long, spreading fan-like as it descended. (The annexed wood-cut, figure 50, will convey an idea of this peculiar and interesting feature : it represents a section across the cave at the point where the depending sheet of ore was observed, as described above.) A part of the way there were three sheets, two thick and heavy ones, with coarse irregular surfaces, composed of aggregated cubes from two inches to ten

Fig. 50.—Section in Levin's cave.

a. Depending mass of galena.
b. Detritus and clay with galena.
c. Cap rock,
d. Galena limestone.

inches on a side, and one thin or light sheet, the whole covered with oxide (carbonate?) of lead, and having, in consequence, a pure white color. This depending mass was wholly clear, except where it was attached to the rock above and projected downwards in space, the most rich and beautiful object I ever saw of a mineral kind. About two hundred feet more of twisting and squirming brought us to the leaden temple, where lay the fortune of our bold explorer. It is a cave, or pocket, some hundred and thirty feet long, twenty feet high in the dome or cavern part, and twenty to thirty feet wide, the sides and roof arched in an irregular manner. Probably it extends in this oval shape to a depth equal to the clear space above. The whole appears to have been ceiled with lead; and although its size is not as great as that of many (?) other mineral caves, the amount of galena in view at any one time is said to exceed that of any 'pocket' yet opened. Much of the lead lining the roof and sides had fallen down in immense blocks, some of them very recently. This mineral incrustation was, in places, two feet thick, and one of the fallen masses was estimated to weigh twenty-three thousand pounds. In the mud and clay that formed the bottom, or floor, of this spacious room, they said that mineral would be found buried, or enclosed, in large lumps to the bottom, probably fifteen feet deeper."

Such was the appearance of things at this most interesting locality, certainly one of the most remarkable ever discovered, in 1850. In October, 1852, about two million pounds of ore, worth, at the then current price of lead, about fifty thousand dollars, had been removed; and there was still left in the mines about one and a half millions of ore, which was

taken out in 1853 and 1854. A shaft had been sunk from the surface to strike the rich cave spoken of above, the top of which was reached at the depth of about ninety feet, and the bottom of the excavation was above forty-five deeper. The length to which the crevice had been traced was about twelve hundred feet; and the cave-like expansion extended for nearly three hundred feet, widening out in some places to twenty-five feet. The galena at this time could be seen, in some places, occupying a fissure extending upwards into the cap rock: it also formed flat sheets running into the sides of the opening, in some places, with a thickness of three or four inches of solid ore; but by far the larger portion lay in loose masses in the bottom of the elliptical cave-like opening, mixed with clay, sand, and loose masses of partially disintegrated limestone, called "tumbling rock." Besides the shell-like deposit of ore which lined the walls of this cave, as described by Mr. Whittlesey, there seem to have been horizontal layers which once extended through the opening; these had been broken up, and the rock surrounding them removed by the action of currents of water, of which the evidence could be seen in every part of the crevice, especially in the water-worn and grooved lower surface of the cap rock, and in the rounded edges and angles of the projecting strata of the sides of the opening.

Kerrick and Jones's Lode. This is one of the most important and interesting deposits of lead which has been worked in recent years. The crevice is remarkable for its length and regularity as well as for its productiveness, it having already yielded over a million and a half of ore. It has almost exactly an east and west direction, the magnetic bearing between the shafts, proceeding in a westerly direction, being from No. 1 to No. 2, S. 85° W.; No. 2 to No. 3, S. 83° W.; No. 3 to No. 4, S. 83½° W. (the magnetic variation is about 8° E.). It has been opened for a length of nearly fifteen hundred feet, having a width of from six to eight feet, except where divided into two portions by the "key rock," when it widens out to twelve or fifteen.

At the time this locality was visited by us, in October, 1857, the end of the drift going west was distant about three hundred feet from the engine-shaft, and the crevice presented the appearance represented by the annexed section (Fig. 51),

its width at this point being about six and its height eight feet. The opening was filled with soft clay; the ore occupying a fissure extending upwards in the top of the drift and having a width of nineteen inches (represented at *a* in the figure), all of which was solid galena, with the exception of a narrow irregular space in the centre, the ore having crystallized on both sides of the fissure, but not filling it up entirely. Twenty feet before reaching this point, a solid sheet of mineral had been struck, which extended from the floor to the top of the crevice. Between this point and the shaft the crevice appears to have a quite variable height, the excavation having a height of forty or fifty feet, the crevice extended upwards in the cap rock and carried ore for a considerable distance. A section of the crevice at another point is represented in the annexed wood-cut (Fig. 52), which shows the position of the so-called "key-rock," an irregular mass of limestone remaining undecomposed along the centre of the crevice, which divides into two parts, as is frequently the case in wide vertical openings: this disposition resembles the splitting of veins, so as to include large masses of rock, called by the Cornish miners "horses," and which are common in other mining regions.

Fig. 51.—Section at Kerrick and Jones's lode.

Fig. 52.—Section at Kerrick and Jones's lode.

The workings on the crevice have been several times suspended and resumed, on account of the abundance of water, the shaft having reached a depth of one hundred and ten feet. After several abortive attempts to introduce new-fangled and ill-contrived machinery for pumping, a steam engine was erected in 1857, which operated a suitable pump with 21-inch lifts, raising seven hundred gallons per minute,

and with the aid of which it was intended to sink the shaft twelve feet deeper.

This was the only locality, at this time, where steam power was in use on this side of the river for draining a mine. Another engine was erecting at Riley's lode, a few rods south of this, and which had been worked for some years, over an extent of several hundred feet longitudinally and to a depth of a hundred and thirty-seven feet, and much mineral raised; two millions, it is said. The crevice, which was not accessible, was found to be almost exactly parallel with that of Kerrick & Jones, its mean direction being N. 86° E., S. 86° W., magnetic

---

ART. II.—ON THE METALLURGY OF LEAD.—By John Arthur Phillips.

[*Continued from December Number.*]

Concentration of the Silver.—This process founded on the circumstance first noticed in the year 1829, by the late H. L. Pattinson of Newcastle-on-Tyne, that when lead containing silver is melted in a suitable vessel, afterwards slowly allowed to cool, and at the same time kept constantly stirred, at a certain temperature near the melting point of lead, metallic crystals begin to form. These, as rapidly as they are produced, sink to the bottom, and on being removed are found to contain much less silver than the lead originally operated on. The still fluid portion, from which the crystals have been removed, will at the same time be proportionally enriched.

This operation is conducted in a series of eight or ten cast-iron pots, set in a row, with fire-places beneath. These are each capable of containing about 6 tons of calcined lead; and on commencing an operation, that quantity of metal, containing, we will suppose 20 oz. of silver per ton, is introduced into a pot (say No. 4) about the centre of the series. This, when melted, is carefully skimmed with a perforated ladle, and the fire immediately withdrawn. The cooling of the metal is also frequently hastened by throwing water upon its surface, and whilst cooling it is kept constantly agitated by means of a long iron stirrer or slice. Crystals soon begin to make their appearance, and these as they accumulate and fall

to the bottom, are removed by means of a large perforated ladle, in which they are well shaken, and afterwards carried over to the next pot to the left of the workman. This operation goes on continually, until about 4 tons of crystals have been taken out of the pot No. 4, and have been placed into pot No. 5, at which time the pot No. 4 may contain about 40 oz. of silver to the ton, whilst that in No. 5 will only yield 10 oz. The rich lead in No. 4 is then laded into the next pot No. 3, to the right of the workman, and the operation repeated in No. 4, on a fresh quantity of calcined lead.

In this way calcined lead is constantly introduced, and the resulting poor lead passes continually to the left of the workman, whilst the rich is passing towards his right. Each pot in succession, when filled with lead of its proper produce for silver, is in its turn crystallized, the poor lead passing to the left of the workman, and the enriched lead to his right. By this method of treatment, it is evident that the crystals obtained from the pots to the left of the workman must gradually be deprived of their silver, whilst the rich lead passing to his right becomes continually richer. The final result is, that at one end of the series, the poor lead contains very little silver, whilst at the other an exceedingly rich alloy of lead and silver is obtained.

The poor lead obtained by this process should never contain more than 12 dwts. of silver per ton, whilst the rich lead is frequently concentrated to 500 oz. to the ton. This rich lead is subsequently cupelled in the refining furnace.

The ladle employed for the removal of the crystals, when manual labor is made use of, is about 16 inches in diameter, and 5 inches in depth, but when cranes are used much larger ladles are easily managed. A form of crane has been invented by Mr. J. Sparks, which effects considerable economy of labor. When, during the operation of crystallization, the ladle becomes chilled, it is dipped into a small vessel containing lead of a higher temperature than that which is being worked, and known by the name of a temper-pot. The pot containing the rich lead is often called the No. 1 pot ; in some establishments, however, the last pot in which the pure lead is crystallized obtains this appellation.

The cost of crystallizing one ton of calcined Spanish lead in the establishment quoted when treating of calcination, is as follows :

	s.	d.
Wages	9	5.4
Coals, 4 cwts	0	8.4
Repairs	0	2.5
Total	10	4.3

The erection of nine six-ton pots requires 15,000 common bricks, 10,000 fire-bricks, 160 feet of quarles, 80 fire-clay blocks, and 5 tons of fire-clay.

In some establishments ten-ton pots are employed, and where cranes are made use of they are found to be advantageous.

Refining.—The extraction of the silver contained in the rich lead is conducted in a cupel, forming the bottom of a reverberatory furnace called a refinery.

In this operation the litharge produced, instead of being absorbed by the substance of the cupel, is run off in a fluid state, by means of a depression called a gate.

The size of the fire-place varies with the other dimensions of the furnace, but is usually nearly square, and in an apparatus of ordinary size may be about 2 feet by 2 feet 6 inches. This is separated from the body of the furnace by a fire-bridge 18 inches in breadth, so that the flame and heated air pass directly over the surface of the cupel, and from thence escape by means of two separate apertures into the main flues of the establishment. The cupel or test consists of an oval iron ring, about 5 inches in depth, its greatest diameter being 4 feet, and its lesser nearly 3 feet. This frame, in order to better support the bottom of the cupel, is provided with cross bars about 4½ inches wide, and one half inch in thickness. In order to make a test, this frame is beaten full of finely-powdered bone-ash, slightly moistened with water, containing a small quantity of pearl-ash in solution, which has the property of giving consistency to the cupel when heated.

The centre of the test, after the ring has been well-filled with this mixture, and solidly beaten down, is scooped out with a small trowel, until the sides are left 2 inches in thickness at top, and three inches at the bottom, whilst the thickness of the sole itself is about 1 inch.

At the fore part or wide end of the test the thickness of the border is increased to six inches, and a hole is then cut through the bottom, which communicates with the openings or gates by which the fluid litharge makes its escape.

The test, when thus prepared, is placed in the refinery furnace, of which it forms the bottom, and is wedged to its proper height against an iron ring firmly built into the masonry. When this furnace is first lighted, it is necessary to apply the heat very gradually, since if the test were too strongly heated before it became perfectly dry, it would be liable to crack. As soon as the test has become thoroughly dry, it is heated to incipient redness, and is nearly filled with the rich lead to be operated on, which has been previously fused in an iron pot at the side of the furnace, and beneath which is a small grate where a fire is lighted.

The melted lead, when first introduced into the furnace, becomes covered with a grayish dross, but on further increasing the heat, the surface of the bath uncovers, and ordinary litharge begins to make its appearance.

The blast is now turned on, and forces the litharge from the back of the test up to the breast, where it passes over the gate, and falls through the aperture between the bone-ash and the ring into a small cast-iron pot running on wheels. The air, which is supplied by a small ventilator, not only sweeps the litharge from the surface of the lead towards the breast, but also supplies the oxygen necessary for its formation.

In proportion as the surface of the lead becomes depressed by its constant oxidation, and the continual removal of the resulting litharge, more metal is added from the melting pot, so as to raise it to its former level, and in this manner the operation is continued until the lead in the bottom of the test has become so enriched as to render it necessary that it should be tapped. The contents of the test are now so far reduced in volume, that the whole of the silver contained in the rich lead operated on remains in combination with a few hundred weights only of metal, and this is removed by carefully drilling a hole in the bone-ash forming the bottom of the test. The reason for the removal of the rich lead, is to prevent too large an amount of silver from being carried off in the litharge, which is found to be the case when lead containing a very large amount of that metal is operated on.

When the rich lead has been thus removed, the tapping hole is again closed by a pellet of bone-ash, and another charge immediately introduced.

As soon as the whole of the rich lead has been subjected

to cupellation, and has become thus further enriched, the argentiferous alloy is itself similarly treated, either in a fresh test, or in that employed for the concentration of the rich lead. The brightening of pure silver at the moment of the separation of the last traces of lead, indicates the precise period at which the operation should be terminated, and the blast is then turned off, and the fire removed from the grate. The silver is now allowed to set, and as soon as it has become hardened, the wedges are removed from beneath the test which is placed on the floor of the establishment. When cold, the silver plate is detached from the test, and any adhering particles of bone-ash removed by the aid of a wire brush.

A test furnace of ordinary dimensions requires for its construction about 2,000 common bricks, 2,000 fire-bricks, and 1½ tons of fire-clay. A furnace of this kind will work off 4 pigs of lead per hour, and consume 4 cwts. of coal per ton of rich lead ore operated on.

The cost of working a ton of rich lead in the neighborhood of Newcastle, containing on an average 400 oz. of silver per ton, is as follows :—

	s.	d.
Refiner's wages	4	2.1
Coals 4 cwt	0	6.8
Engine wages	1	7.0
Coals 5 cwt	0	8.7
Pearl-ash	0	3.5
Bone-ash 17.3 lbs	3	1.0
Repairs	0	5.0
Total	10	10.1

Reducing.—The reduction to the metallic state of the litharge from the refinery, the pot dross, and the mixed metallic oxides from the calcining furnace, is effected in a reverberatory apparatus, somewhat resembling a smelting furnace, except that its dimensions are smaller, and the sole, instead of being lowest immediately below the middle door, gradually slopes from the fire-bridge to near the flue, where there is a depression in which is inserted an iron gutter, which constantly remains open, and from which the reduced metal flows continuously into an iron pot placed by the side of the furnace for its reception, whence it is subsequently laded into moulds.

The litharge, or pot dross, is intimately mixed with a

quantity of small coal, and is charged on that part of the hearth immediately before the fire-bridge. To prevent the fused oxide from attacking the bottom of the furnace, and also to provide a sort of hollow filter for the liquid metal, the sole is covered by a layer of bituminous coals.

The heat of the furnace quickly causes the ignition of this stratum, which is rapidly reduced to the state of a spongy cinder. The reducing gases present in the furnace, aided by the coal mixed with the charge itself, cause the reduction of the oxide, which, assuming the metallic form, flows through the interstices of the cinder, and ultimately finding its way into the depression at the extremity of the hearth, flows through the iron gutter into the external cast iron pot. The surface of the charge is frequently, during the process of elaboration, turned over with an iron rake, for the double purpose of exposing new surfaces to the action of the furnace, and also to allow the reduced lead to more readily flow off.

Fresh quantities of litharge or pot-dross, with small coals, are from time to time thrown in, in proportion as that already charged disappears, and at the end of the shift, which usually extends over 12 hours, the floor of cinder is broken up, and after being mixed with the residual matters in the furnace is withdrawn. A new floor of cinders is then introduced, and the operation commenced as before. A furnace of this kind, having a sole 8 feet in length and 5 feet in width, will afford, from litharge, about 4¼ tons of lead in 24 hours, and will consume 20 cwt. of coals.

The dross from the calcining pan, when treated in a furnace of this description, should be previously reduced to a state of fine division, and intimately mixed up with small coal and a soda-ash. In many cases, however, the calcined dross is treated in the smelting furnace. The hard lead obtained from this substance is again taken to the calcining furnace, for the purpose of being softened.

The expense of reducing one ton of litharge may be estimated as follows :—

	s.	*d.*
Wages	2	6.0
Coals (3 cwts.)	0	5.2
Repairs	0	1.6
Total	3	0.8

In the establishment from which the foregoing data were

obtained, the cost of slack, delivered at the works, was only 2s. 11d. per ton, which is cheaper than fuel can be obtained in the majority of the lead mills of the country. In North Wales the cost of small coal is generally about 4s., and at Bristol 5s. 6d. per ton.

The total cost of elaborating one ton of hard lead, containing 30 oz. of silver per ton, in a locality in which fuel is obtained at the low price above quoted, is nearly as follows:—

	£	s.	d.
Calcining	0	2	4.5
Crystallizing	0	9	6.5
Refining	0	0	9.2
Reducing—pot dross and litharge	0	1	0.8
Calcined dross	0	0	8.0
Slags	0	0	5.0
Bone-ash, &c.	0	0	7.0
Transport, &c.	0	1	1.0
Management, taxes, and interest of plant	0	5	10.0
Total	£1	2	4.0

One hundred tons of hard lead treated gave—

	Tons.
Soft lead	94.90
Black dross	3.72
Loss	1.38
Total	100.00

On comparing the expense of each operation, as given in the foregoing abstract, with the amounts stated as the cost of each separate process, they will be found to be widely different, but it must be remembered that the whole of the substances elaborated are far from being subjected to the various treatments described.

In order therefore to give an idea of the relative proportions which are passed through the several departments, I may state, that in an establishment in which the ores are treated in the Castillian furnace, the following are the results obtained:—

One hundred parts of raw ore yield:—

Roasted ore	85
Hard lead	42
Soft "	36
Rich "	9
Dross and litharge re-treated	18½

The importance of this branch of our metallurgic industry will be gathered from the following tabular statements, chiefly derived from Mr. Hunt's valuable statistics:—

TABLE I.

TABLE showing the quantity of Lead Ore raised and smelted, average Metallic yield of Ore per cent., and Ratio of Lead produced in various parts of the United Kingdom during ten years ending 1857.

YEARS.	ENGLAND.		WALES.		IRELAND.		SCOTLAND.		ISLE OF MAN.		TOTAL.	
	Lead Ore.	*Lead.*	*Lead Ore.*	*Lead.*	*Lead Ore.*	*Lead.*	*Lead Ore.*	*Lead.*	*Lead Ore.*	*Lead.*	*Lead Ore.*	*Lead.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1848	54,538	39,142	16,305	11,122	1,912	1,188	2,588	1,736	2,521	1,665	77,864	54,853
1849	60,124	41,168	19,711	13,389	2,739	1,653	1,421	957	2,826	1,535	86,821	58,702
1850	63,565	44,462	21,093	14,876	2,895	1,746	3,117	2,124	2,175	1,218	92,845	64,426
1851	64,102	45,103	19,314	14,813	3,222	1,829	3,113	2,140	2,560	1,402	92,311	65,287
1852	62,411	43,813	18,379	13,708	4,493	3,222	3,499	2,381	2,415	1,835	91,197	64,959
1858	59,342	41,897	17.131	12,870	3,309	2,452	2,799	1,919	2,460	1,829	85.041	60,967
1854	64,796	44,986	18,130	13,367	3,069	2,210	1,753	1,279	2,800	2,137	90,548	63,979
1855	66,270	46,244	18,206	13,673	2,405	1,732	1,587	1,159	3,573	2,725	92,041	65,533
1856	74,489	52,868	19,873	14,791	2,484	1,602	1,931	1,417	3,218	2,451	101,997	73,129
1857	68,520	48,356	21,455	16,124	2,299	1,407	1,891	1,351	2,656	2,028	96,821	69,266
	638,157	448,039	189,597	138,733	28,827	19,041	23,699	16,463	27,204	18,825	907,486	641,101
Average Metallic yield per cent. of Ore........	70.2		73.1		66.0		69.4		69.1		70.6	
Ratio of Lead produced	69.9		21.7		3.0		2.5		2.1		= 100	

TABLE II.

Estimated value of Lead and Silver consumed in Great Britain, 1857.

Lead and Silver produced in the United Kingdom		£1,670,353
Silver imported, 1,846,569 oz		232,806
		1,903,159
Lead exported	22,397 tons.	
" imported	12,768 "	
Balance of exports	9,629	211,838
Value consumed		1,691,321

TABLE III.

Silver produced from Ores raised in Great Britain, during Four Years, ending 1857.

	1854.	1855.	1856.	1857.
	Ozs.	Ozs.	Ozs.	Ozs.
England	419,824	439,983	481,909	417,843
Wales	67,051	57,521	62,357	58,097
Ireland	18,096	7,252	3,700	3,071
Scotland	5,426	4,947	5,289	4,206
Isle of Man	52,262	51,597	60,382	48,516
	562,659	561,300	613,637	530,733
Value at 5s. 6d. per oz.	£154,730	£154,357	£158,750	£146,501

Market Value of Lead produced in the United Kingdom in 1857	£1,523,852
Ditto of Silver	146,501
	£1,670,353

It would be evidently impossible to comprise within the limits of a single paper, a description of the whole of the various processes employed in different parts of the world for the reduction of lead from its ores, and I have consequently confined myself to an exposition of the general routine of the operations commonly practised in this country.

In doing this, it has been my endeavor to furnish reliable data as to the expenses and losses incurred in each

operation, and although it would have been easy to have multiplied examples, want of space has prevented my doing so.

It is in the treatment of ores of good produce that the reverberatory furnace and Scotch hearth are to be preferred, but for working minerals of a low percentage, the blast furnace may generally be substituted with advantage. The slag hearth, from the amount of fuel consumed and loss experienced, is a somewhat expensive apparatus, and might, in many cases, be advantageously exchanged for the Castillian furnace.

It is well known that the losses which take place in this branch of metallurgy are, from the volatility of the metal operated on, unusually large. In those establishments, however, in which due attention is paid to fluxes and a proper mixture of ores, as well as the condensation of the fumes, a great economy is effected.

In lieu of long and extensive flues, condensers of various descriptions have from time to time been introduced, but in most instances the former have been found to be more efficient.

DISCUSSION.

The Chairman [Robt. Hume, Esq.] said, if he understood rightly the object of the Society of Arts, he thought that such papers as the one brought before them that evening fully carried out its intention. Mr. Phillips had detailed to them the processes which were employed in the smelting of lead ores up to the latest improvements which had been introduced. Still it would be admitted by him, and he was sure it would be admitted by others familiar with the subject, that there remained great improvements to be made, for we were still suffering an enormous loss from the imperfections of even the best known processes. They might, therefore, hope that some gentlemen might be induced to offer some remarks upon these points, and the result might be the quickening of some dormant thought, which might lead to improvements in this branch of manufacture. He thought it would not be out of place to refer to one individual, to whom we were specially

indebted for much progress in this department of metallurgy. Mr. Phillips had referred to the process invented by Mr. Hugh Lee Pattinson for extracting the silver from lead ores. Within the last year that gentleman had been taken from them; and he thought this was a legitimate opportunity for acknowledging the debt of gratitude that we owed to him. He was in every respect a remarkable man. When a poor boy, in a small druggist's shop, in the little town of Alston, he taught himself chemistry, never having had an instructor. He was in every sense of the word a self-taught man; and he was a most industrious one, a most earnest worker, and a man of the closest and of the keenest powers of observation. He was led, amongst other things, by seeing the process of lead smelting that was going on in his own immediate vicinity, to direct his attention to the means of separating the silver from the lead, and after making a series of experiments, he succeeded in producing a process which, for a long period of years, saved not less than 200,000 ounces of silver annually, which had previously been thrown away. Not only had this self-educated man effected this, but he had introduced another useful product from the lead ores, the oxy-chloride of lead, and had also given us a process for the preparation of the carbonate of magnesia from the dolomite, or magnesian limestone of the North of England. There was, however, nothing more remarkable in the career of this distinguished man than the way in which he bestowed the fortune which his industry secured to him, in promoting the best interests of those around him. In the neighborhood of the works, now carried on by his family, he established schools, in which hundreds of workmen and children were educated. His was, therefore, a name, in connection with this subject, which he could not allow to pass without the brief comments which he had ventured to make.

Mr. Hyde Clarke, on being called upon by the Chairman, said he had not such a practical acquaintance with the various branches of metallurgy as Mr. Phillips possessed, and he had had very little to do with lead smelting. Mr. Phillips's observations, however, had tended very much to draw his attention to one subject which had been adverted to—viz., the importance of considering the operations of smelting as a whole, when working for the improvement of any particular process. It certainly was a great misfortune that in metal-

lurgical pursuits, too many practical men were absorbed in their own particular branch, without studying the other branches; whereas, in reality, there were very few processes which, if carefully examined, would not be found capable of affording some hint for the improvement of other departments of metallurgy. It was a subject to which, he trusted, Mr. Phillips himself would be induced to turn his attention, for the purpose of carrying out those practical objects which the Chairman had mentioned. There were few branches of metallurgy in which serious losses were not sustained by the employment of some old process, whereas, in other departments of industry, many important improvements had been introduced. The observation made by the Chairman with reference to the late Hugh Lee Pattinson, had brought to his mind another subject—the neglect of so many important mineral products which still existed in this country, notwithstanding all the improvements made. With regard to the particular subject of silver in lead, he had in his own museum specimens collected 50, 60, or 80 years ago, of lead ore containing 40, 60, and 80 ounces of silver to the ton, which were left unwrought for years, because it was considered that they were not susceptible of economical application; whereas, by the improvements introduced, the production of silver in this country had become very considerable, a subject with which no one was better acquainted than the Chairman. Those improvements had been the means of realizing a very great quantity of silver from ores the produce of this country, besides which, the improvements of Pattinson and others had enabled them to treat a large quantity of foreign ores brought to this country for that purpose. The great increase which had taken place in the production of silver in this country, was an encouragement for the carrying out of similar improvements. They had recently had a paper read before the Society upon the utilization of waste substances, and he would renew the remark which he made on that occasion, viz., that in no branch of manufacture was there greater waste than in their metallurgic operations, and every process by which they could economize the substances now wasted was worthy of the highest consideration.

The Rev. Daniel Ace said, having formerly had the charge of the parish of Alston, it was his privilege to come in contact with the late Mr. Hugh Lee Pattinson, and he could testify

that a more humble and liberal-minded man he was never privileged to converse with; for, notwithstanding his high attainments in science, he was ever ready to communicate his knowledge to others, and to do his utmost to promote the happiness of those with whom he was associated. In a religious point of view, he was desirous to promote that independence of thought, as well as liberality of action, which he (Mr. Ace), as a clergyman, conceived to be the glory of mankind.

Mr. Warrington expressed the pleasure he had derived some years since, from a visit to the smelting-works at Alston Moor, at which time, the flue which was suggested by Bishop Watson extended for a distance of three miles. He believed it was now considerably longer. From that place an enormous quantity of soot was annually taken, and he believed as much as 300 tons of lead was derived from that flue, which would have been driven off into the atmosphere as smoke, destroying vegetable and animal life.

Mr. J. A. Phillips said the fumes caught in well-constructed flues, generally amounted to 1 or 1½ per cent. of the lead contained in the ore put into the furnaces; but the amount of silver was very much smaller; and they found that the fumes from ores containing 20 ounces of silver to the ton, would in very few instances contain more than two or three ounces of silver. He had analyzed the fumes from different parts of the flue, and had found that in the first 100 yards, the proportion of silver was greater than in the next 100 yards, until, as the chimney was approached, there were scarcely any traces of silver. Instead of flues, condensers of various kinds had been employed, which were found very efficacious for the condensation of the fumes, and when employed with the Castillian or other blast furnaces, they did not materially impair the draft, since the furnace was not dependent upon the natural draft, but upon a blast forced in by machinery. When, on the other hand, they made use of reverberatory furnaces, a condensing chamber materially checked the draft from the flue, and every practical lead-smelter would bear him out, that it was exceedingly difficult to obtain good results with a furnace having a bad draft. When speaking of the combination of silver and lead in the galenas, he remarked that it would appear in many cases that the sulphide of silver was combined mechanically with the sulphide of

lead; whilst, in other cases, the two sulphides were in a state of chemical combination. Alluding to specimens upon the table, Mr. Phillips remarked that in the case of one of them, the silver was almost entirely lost if the ore was treated by washing, whilst in the other the loss of silver, by similar treatment, did not amount to more than two ounces to the ton. In the first case the sulphide of silver was mechanically combined, and in the second it was in a state of chemical combination with the sulphide of lead. Mr. Hyde Clarke had stated that in the metallurgic operations of the present day there was still a great waste of useful products. No doubt such was the case. There was a great want of chemical knowledge in the mining districts of the country. An instance occurred a short time ago, in which large quantities of oxide of iron usually called "gossan," were thrown away from a mine in Cornwall, it never having occurred to them to test it for silver; on its being examined, however, it was found to contain silver to the amount of £15 per ton, and as it was obtained in large quantities, this discovery materially enhanced the value of the property. He had no doubt that not only silver, but nickel and cobalt existed in much larger proportion in the mineral districts than was generally imagined.

Professor Tennant observed that, on looking over some of the rubbish heaps in Shropshire, which had been cast away as refuse matter, he found a large portion of carbonate of lead, which had been regarded as calcareous spar. There were instances in which the carbonate of lead was apt to be overlooked, even by those who had a practical knowledge of mineralogy, and a valuable product was thrown away simply owing to a want of acquaintance with its properties. He fully agreed with the remark that a better practical education was required amongst the people engaged in mining operations. The late Mr. Hugh Lee Pattinson was one who took that matter in hand, and he was happy to find that the example had been followed in other instances. He would particularly allude to the extensive mines under the superintendence of Mr. Sopwith, where thousands of men were employed. He believed the flue at the works of Alston Moor was nearly five miles in length, instead of three miles, as mentioned by Mr. Warrington. He (Professor Tennant) felt obliged to Mr. Phillips for the way in which he had described the operation

of lead smelting, which was of the utmost importance when they considered its extent. With regard to the statistics of this subject, he believed the Chairman would corroborate the statement that there was often difficulty in obtaining precise information.

The Chairman said that Mr. Tennant was in error. He could with very great satisfaction say that in his statistical inquiries, with but one exception, he had never been refused the information he had asked for.

Professor Tennant was very happy to hear it. He found the value of the metallic minerals in this country was about £16,000,000 per annum; they were therefore a most important part of our national wealth, and any information bearing on the subject was necessarily of great interest. In conclusion, Professor Tennant pointed out the great importance of a more general study of mineralogy, and strongly recommended a visit to the works at Alston Moor, which he said would be highly entertaining as well as instructive.

The Chairman would ask the gentleman who had just addressed them, whether he could give them any information as to the combination of sulphide of silver with sulphide of lead.

Professor Tennant replied, that it was one of those difficult questions which had not yet been fully resolved, like that of the pure silver that was found in the copper of Lake Superior. Whether the combination was chemical or mechanical, he could not say; but his own impression was that the metals were mechanically, and not chemically combined.

Mr. J. A. Phillips said, that some years since he visited the mines of Lake Superior, and had paid some attention to the combination of the silver and copper. He had found some cases in which the two metals seemed to form an alloy, while in others he had found nicely formed crystals of native copper combined with equally well-formed crystals of silver, and on testing those crystals he found both nearly equally pure.

Mr. Hyde Clarke inquired whether it was not the case in the long flues, of which mention had been made, that the deposit of metal was always found in the largest proportion nearest to the furnace, and less towards the further portions of the flue. There was a gentleman present (Mr. John Phillips), who was able to give them some information as to the mining operations in Spain.

Mr. J. A. Phillips said with regard to the deposits in the flues of furnaces, he was not practically acquainted with the working of all the metals, but with reference to those with which he was specially acquainted, he could say that the largest deposits were in the immediate vicinity of the furnace; and in proportion to the distance from the furnace the amount of the deposit decreased. He had also observed that in certain ores—particularly those of silver—the metal was carried off by mechanical action. An old pupil of his engaged in works in Spain had informed him that he invariably found that the deposit of silver was richer near the furnace than elsewhere.

Mr. Hyde Clarke presumed that the stuff at the further end of the flue was not worth taking out.

Mr. J. A. Phillips remarked that in the works in Spain, and elsewhere, where silver ores were treated, the deposit, even at the further end of the flues, contained a sufficient amount of silver to render its collection a matter of importance.

Mr. John Phillips was largely interested in the smelting of lead and silver. The important question now was as to the loss of silver sustained in the operation of calcining the ores. In the works in Spain with which he had been connected, the poorer ores, which only yielded about 4 ounces of silver per 100 lbs. of ore, were calcined in what was known as Brunton's Calciner, which answered well for ores of this description, but with ores of the richer class the process of calcining by manual labor was found to answer best, because the charge was more carefully stirred up, and there was consequently less loss through the ore being carried off by the draught. He was not competent to enter into the chemical part of the subject, but he had no doubt that with careful manipulation the loss might be much diminished. Reverting to the subject of lead smelting, he was glad to hear Mr. Phillips state the result of his observations as to the saving of lead in the flues in the shape of fumes, because it was a matter of great importance. There were some works in Spain, where the loss of lead in the fumes was very great. He particularly alluded to the Linares works, where the Castillian furnaces were employed, and the loss was considerable until they adopted the plan of the long flue. When this was done, the saving during the first month paid a large portion

of the expense of building the flue. Then again a saving in the length of the flue might be made by the use of condensers; and some improvements had been made in the forms of these condensers. One form had been mentioned as having been recently introduced, in which there were a series of falls of water so arranged as to cool the gases without interfering with the draft of the furnace. In the use of these condensers it was most important to take care that the draft was not interfered with. If the draft was kept perfect they were of great value, and saved the cost of erecting long flues.

The Chairman said there were one or two points to which it was important that their attention should be called before this discussion closed. In the first place, branching from the subject, although associated with it, there was one important fact connected with lead. In Durham and Northumberland —taking the year 1857—they had 17,000 tons of lead produced, which gave 74,000 ounces of silver; whilst in Cumberland they found that, with a produce of only 4,700 tons of lead they had 43,500 ounces of silver. Going on to Yorkshire, they found that 7,875 tons of lead were produced, and yet they only obtained from that lead 445 ounces of silver. The remarkable point was, that going southward they found, as they got into Flintshire, with a produce of 2,280 tons of lead, they had 13,300 oz. of silver. With 5,509 tons of lead produced in Cardiganshire, they had 35,000 ozs. of silver. Going farther southward into Cornwall, with 6,000 tons of lead produced in 1857, they had 224,277 ozs. of silver; and in Devonshire, with 1,535 tons of lead produced, they had 50,200 ozs. of silver. There was no question but that there was some law regulating this, and it was a subject which called for inquiry. Again, they had the important lead districts of Derbyshire, producing 6,000 tons of lead, from which it was stated, he believed with some degree of truth, that no silver whatever was obtained. He said, with some *degree* of truth, because the white lead manufacturers, obtaining the material from the Derbyshire smelters, had, by the use of Pattinson's process, obtained silver from the lead, although it was not obtained by the Derbyshire smelters themselves. Mr. Phillips had mentioned the extraordinary case of "gossans," in connection with a mine in Cornwall, containing a large quantity of silver. This had been further exemplified

in Cambourne, in Cornwall, where the fissures, in some cases at right angles to the main lode, and in others parallel to it, were found to contain an enormous quantity of silver existing as a chloride of silver mixed with the oxide of iron. Whilst waiting at the Cambourne station one day, he saw two tons of that material sent away, which was said to be worth £3,000, from the silver it contained. Mr. Phillips had also mentioned the importance of looking for nickel and cobalt. There was every reason to believe that Cornwall contained large quantities of cobalt, which was now thrown away. This metal having been found in large quantities in the sandstone formation of Alderly Edge, some 50 years ago, a gentleman of Liverpool established works at that place for the preparation of smalt, but the excise came down upon him for the glass duty, and he was surcharged to an extent that ruined him: works, however, were being again established in that place. Cobalt also existed to a great extent in Cumberland, although our principal supply was obtained from the German, Norwegian, and Swedish mines. The chairman further mentioned a curious fact connected with the mines of the Duke of Devonshire. At Grassington, the lead was found only in the bands of limestone, and none whatever existed in the shale, whilst at a distance of ten miles off, at Connolly, the lead was found entirely in the shale, and none in the limestone. The cause of this he was not in a position to explain; but it was important that a better series of observations should be made and recorded. He fully agreed with what had been said by Professor Tennant as to the want of better education of a practical nature amongst the mining community, and those connected with mineralogical pursuits. He was sure they were losing a large amount of valuable products, from the want of proper knowledge upon the subject. As an example, he might mention that they were producing large quantities of sulphur from the iron pyrites of Wicklow, which was conveyed to St. Helen's to be manufactured into sulphuric acid, and the material remaining from that manufacture which was formerly thrown away, was now disposed of to another house, and being roasted with common salt, copper was produced as a muriate and precipitated by iron, and a chloride of silver was likewise produced, which, being dissolved out by a strong brine, was afterwards precipitated by zinc. The silver cake was sent to the metropolis, and instead of fetching the usual price

of 5s. per oz. it brought from 8s. to 10s. per oz., on account of the gold it contained. This showed what could be done with a proper knowledge of the subject. He had now to propose a vote of thanks to Mr. Phillips for the valuable paper he had brought before them on the present occasion.

Art. III.—MINING LAWS IN THE TERRITORIES.

Wm. P. Blake, Esq., Editor of the Mining Magazine:

By your late number of the *Mining Magazine*, I perceive that you are fully aware of the immense importance which silver and copper mining in the new Territories is assuming. This is a new field for the display of American energy, and will produce results that must astonish the world. Arizona especially deserves our particular attention, as its rugged mountains teem with ores of the richest description, known not from hearsay or vague traditional rumors, but from positive facts brought to light through the labor and energy of our own pioneers, assisted by the capitalists of the east. To develop these hidden riches, however, there are various and serious obstacles to overcome, owing to the isolation and destitution of the country, the want of protection against thieving marauding Indians, and the absence of laws, especially those that shall define the miner's rights, privileges, and duties, and that shall settle the question of title to any mineral deposit discovered by enterprising explorers. Before expending money in such a region, capitalists will naturally want to know what guarantee there is for holding the locations where their money is invested. This unfortunate state of things can be remedied only by the enactment of suitable laws by Congress. I do not know of a more appropriate vehicle for bringing this important subject to the attention of the mining public and our legislators than your *Mining Magazine*, so national in its character. I therefore send you a rough sketch of such a law as, in my opinion, is needed. It is, as stated, only a rough suggestive sketch, and may be much improved, but I believe all the important points are mentioned, at least those essential to procure the grand object—that of unravelling a part of the nation's wealth, now lying dormant in a barren, useless country. Such a law ought to be liberal and just, and prevent monopolies and speculation; but it ought, by no means, to drive capital out of the field, for without liberal protection those resources will remain hidden.

I hope that my suggestions will, at least, be a beginning of a discussion of the merits of the subject.

Respectfully, your obedient servant,

HERMAN EHRENBERG, C. E.

NEW YORK, December 1, 1859.

An Act for the Encouragement and Protection of Mining Enterprises in the Territories of the United States.

ARTICLE I.—Be it enacted, that any person discovering or opening a vein, or other mineral deposit, in the territory of the United States, not actually worked or legally owned by other parties, or registered in accordance with this act, shall, by properly denouncing the same, been titled to one forty-acre tract of land, covering such deposit of minerals. Said tract to be located in the form of a square, each side having a length of four hundred and forty yards; and two of which sides shall conform as nearly as possible to the general direction of the vein, this being determined by the person claiming. As such boundary will not, or cannot well conform to the regular lines of the U. S. surveys, but will throw the mineral tracts on two or more forty-acre tracts, of the regular sectionized lands; the claimant shall be entitled to the priority of purchasing at the established rates, all such forty-acre tracts, within which, the boundaries of his particular mineral claim may fall in part: Provided, that in no case shall any one such mineral claim or tract, extend over, and occupy more than four such forty-acre tracts, and the boundaries shall be accordingly arranged.

ARTICLE II.—If, after survey of the public lands, it shall be found that the mineral claims of different parties extend in part, over one and the same forty-acre tract, then this forty-acre tract shall be divided between them, in proportion to the ratio of the area of the portions of the mineral tracts of the respective claimants projecting into it. The division lines and their direction shall, if disputed, be settled by a board of arbitration, presided over by the Surveyor-General, or his authorized deputy.

ARTICLE III.—If two or more persons are associated, and have formed a company for the exploration and the working of mines, and one or several shall make discoveries of mineral deposits in consequence thereof, then each and every one of such company, engaged in exploration, shall be entitled

to the same privilege and claim as enumerated in Articles 1 and 2 of this act, and their claims, or mineral tracts, shall become joint property: Provided, that no company, however large and numerous, shall have the right to register and to take possession of more than four such forty-acre mineral tracts, on, or over the same mineral vein or deposit. Such company shall have the right to locate their forty-acre tracts either contiguous, or in *two*, but no more separate bodies, in case the vein should prove unproductive in a part of its course.

Article IV.—All such discoveries made by either one or several of such company, shall be the property of the whole company, and shall be registered as such, and in the name of such company.

Article V.—Companies holding claims according to the provisions of Articles 4 and 5, shall elect an agent or agents, whose duty it shall be to reside near or on the mineral tracts so claimed; who may be the manager, or any other officer of the company.

Article VI.—It shall be lawful and obligatory upon all such companies, to have their copartnership and articles of agreement, registered with the Clerk of the County where they keep their office, and where their mines are situated; of which they shall procure a certificate, which at all times shall be good evidence in all courts of justice.

Article VII.—Most of the mineral deposits being situated in localities which are devoid of fuel, timber, water, and other necessaries for the successful smelting and reduction of ores, it shall be lawful for each claimant of one mineral tract, to locate and take possession of one 160-acre tract of land, in such locality as may satisfy these demands. But no company, however large, shall, by this act, be entitled to locate more than four such 160-acre tracts of land, which shall be known by the name of "Auxiliary Lands." The boundaries of these shall conform to the lines of the public surveys.

Article VIII.—Any person, or persons, shall have the right to locate on, and work on one or several distinct different veins or mineral deposits, at the same time, and to secure for each distinct vein the corresponding number of auxiliary lands mentioned in Article 7.

Article IX.—All the foregoing articles shall have reference only to the public lands of the United States not already legally claimed by other persons.

ARTICLE X.—Whenever two or more parties or persons explore and prospect one and the same vein, and at about the same time, but at different places, and without knowledge of each other; then he or they, who shall prove first occupancy, shall have the right of first location, taking the principal point of excavation as a centre of their claim or claims on such vein or deposit, and lay off their claim or claims on each side along the general direction of such deposit. The other parties shall proceed by these same laws, after the first have fixed their boundaries. Should there be left vacant ground, between the different parties, then it shall be at the option of the first discoverers, so to change their boundaries, as shall best suit them, and have them recorded accordingly. Any other parties shall locate in order of the time of their arrival on the vein.

ARTICLE XI.—Whenever two or more parties select the same vein, &c., for exploration, and the parties first on the ground, knowing the other parties to be at work, should fail to give warning, either verbal or in writing, of their priority claim on such deposit, then the portion of the vein, situated between the main excavations of the two parties, shall be equally divided between them, irrespective of the number of members each company may have: Provided, that the intervening portions shall not exceed the quantity of land allowed by this act.

ARTICLE XII.—It shall be the duty of all claimants of mineral and auxiliary tracts, to at once define the extent and the boundary of them, as nearly as possible, by good substantial monuments or other conspicuous marks, and to have them recorded, within *three* months from the time of first claiming them, at the Register's office to be established by this act. Such record shall give a faithful description of the tracts—their boundaries—the character and bearing of the vein, and its connection with natural monuments or conspicuous objects in the vicinity.

ARTICLE XIII.—It shall be the duty of all claimants of mineral tracts to sink at least one shaft of thirty feet in depth, or to run a tunnel of fifty feet in length in the body of the vein, or in the adjoining rock, so as to test the vein from the surface, for the purpose of ascertaining the character and capacity of such mineral deposit, within the space of one year from the day of first taking possession thereof; also to erect dwellings thereon in that time, and have a new record made,

at said Register's office, setting forth the results obtained by the requisition of this article, and their future intention of working the deposit. Within the same period, each mineral and auxiliary tract shall be surveyed by the U. S. surveyor, and distinctly marked out on the ground; giving the distances and bearings of at least two of the corners of the main shaft—the general course of the vein, and the bearings and general relations to natural or artificial points in the vicinity.

ARTICLE XIV.—No single person, or company, shall be compelled to sink shafts, or make other improvements on more than one of the tracts of land claimed by him or them—for the same vein or mineral deposit. He or they, on the contrary, shall be allowed to concentrate labor, capital, and energy to any one single point, which to him or them, shall seem best suited to ascertain, to the best advantage, the general character, quality, and capacity of that particular vein or mineral deposit.

ARTICLE XV.—After the first year's registry mentioned in Article 13, it shall be obligatory upon claimants to such mineral tracts, to hold actual possession of them, and work the vein; which obligation shall be considered as complied with by having at least four men actually at work in excavation, for each and every mineral tract claimed and recorded, for at least 200 days in each year.

ARTICLE XVI.—After the expiration of three years, counting from the date of the first or preliminary record mentioned in Article 12, it shall be lawful for all claimants of mineral and auxiliary tracts, to apply at the said Register's office for certificates of having complied with all the requirements of this act, and to present the same to the Surveyor-General of the United States, with the amount due for the enclosed and claimed number of acres. After which presentation, a patent in fee simple shall be issued for the tract or tracts in question. Such application for patents shall be accompanied by a general statement of the condition and quality of the mineral deposit; the number of men actually at work; the mode of reduction employed, and a general view of the results obtained. It shall also be accompanied by three specimens taken from different parts of the work, which said specimens shall be numbered and described, and be preserved for the use of a territorial Museum and Mining school to be established hereafter.

ARTICLE XVII.—Any claimant or claimants not complying with any of the foregoing conditions and obligations, shall forfeit all rights to any such recorded or unrecorded claims to mineral and auxiliary tracts ; and it shall not be lawful for him or them to register such claims anew, within a period of three years after such forfeiture. All such tracts shall again revert to the U. S., and be free for working and registry to any but those excepted in this article.

ARTICLE XVIII.—All mineral deposits, situated on public land, which have not been worked and occupied since the acquisition of the so-called Gadsden Purchase, up to the 1st day of January, 1858, shall be considered as abandoned.

ARTICLE XIX.—All mineral deposits that have thus been, or may be abandoned hereafter, shall in all cases and respects be governed by the laws regulating the opening and working of new veins or deposits.

ARTICLE XX.—Any mine, vein, or mineral deposit being abandoned or forfeited in accordance with this act, and registered anew by other parties, it shall be obligatory upon these parties to give the previous owners warning thereof, so as to remove from the tract, within the space of six months, any thing he or they may deem valuable and useful. Such warning shall be given in the nearest newspaper, and by posting it, at three of the most conspicuous places in the county where the mine is situated. Six months after the expiration of such warning, any and all buildings, furnaces, arrastras, metals, and every other species of property, which may still remain on the ground, shall become the undisputed property of the new claimant, without compensation of any kind, to any person whatsoever.

ARTICLE XXI.—All the minerals, woods, waters, and vegetation found within the boundaries of any tract of land, registered and claimed for mining, grazing, agriculture or any other legal purposes, shall, in conformity with the general customs of the United States, belong to him or them absolutely, who is legally entitled to the possession of the land, wherein, or whereon they are situated : Provided, that no one shall have a right to prevent transient persons from using the waters along the public highways, where they were provided by nature in natural tanks, springs, streams, or otherwise.

ARTICLE XXII.—No person shall have the right to impede or inconvenience travelling, by fencing up the public

roads, filling them up with rubbish, or undermine them, so as to endanger their safety. Neither shall any person change their established direction, without sanction of the proper authorities.

ARTICLE XXIII.—No person shall change his original monuments or boundaries of mineral or other lands. But if a subsequent investigation make this convenient or necessary, and it can be done without prejudice to other parties, then such changes may take place, provided they are properly recorded, and the new boundaries and monuments fixed at once when the original ones are removed.

ARTICLE XXIV.—Whenever it becomes necessary or advantageous to drive tunnels for the purpose of drainage, ventilation, or the better hauling of ores or other subterraneous products or mining materials, it shall be lawful for any party or parties to construct such tunnel or drift, through all private or public property: Provided, that all damages arising from such subterraneous works to other parties, not the U. S., shall be paid by the parties for whose benefit such tunnelling is done. But no damages shall be paid on public lands, where claim for them may be set up, after such tunnel has been projected or actually taken in work: Provided, that the lapse of time between projection and actual work, shall not exceed ninety days, and that the tunnelling parties give timely notice of their project, to any new claimant of the so-affected ground.

ARTICLE XXV.—Whenever such tunnel, as mentioned in Article 24, shall intersect or traverse mineral deposits, or run along lodes, claimed and held by other parties, then it shall be at the option of the owners of such deposits, either to pay one-half the expense of excavation, for the distance that such tunnel runs through their metals, and receive the whole of the ores excavated; or to divide these ores with the tunnelling party, the latter paying all expenses of excavation. Or it shall be optional to either party to abandon all claim to the ores excavated.

ARTICLE XXVI.—If in the construction of such subterraneous works, new veins or deposits are encountered, in ground not claimed or owned by other parties, they shall become the property of the party for whom such tunnel is constructed; and they shall be denounced and registered as is required of new mines, and they shall be governed by the same laws, as stated in this act.

Article XXVII.—The extraction of gold from alluvial and diluvial deposits, generally termed Placer-mining, shall not be considered mining proper, and shall not entitle persons occupied in it, to the provisions of this act; nor shall any article of this act be so construed as to refer to the extraction of gold from the above-mentioned deposits.

Article XXVIII.—There shall be offices established in the different mining centres of the territories, for the registry of mineral and auxiliary lands, which, for the western portion of New Mexico, or Arizona proper, shall be near, or in the Santa Cruz Valley, and the Surveyor-General of the territory, or his authorized deputy, shall be ex-officio Recorder thereof. He shall cause to be kept at his office a Book of Record A, for the preliminary registry of mineral and auxiliary claims to lands, as stated in Article 12 of this act.

He shall keep another Book B, for the final record as explained in Article 13.

And he shall keep one Book C, for the purpose explained in Article 16 of this act.

He shall keep rooms and cases for the preservation of specimens, and have them properly numbered and registered in a Book D, giving the locality whence taken, and also all matters interesting to scientific, legal, and practical purposes.

He shall keep a seal of office, and affix the same to all official documents.

He shall be allowed and receive from all parties interested, the following fees, viz.:

For each preliminary record and certificate in Book A, of one mineral tract, ...	$3 00
For every succeeding claim, on *the same* deposit, and belonging to *the same* parties, . . .	2 00
For final record in Book B, and certificate of one mineral claim, ...	4 00
For every succeeding claim, on *the same* deposit, for *the same* parties, ...	2 00
For all records and certificates in Book C, of *one* tract,	4 00
For every succeeding claim, for *the same* party, *on the same* deposit, ...	2 00
For recording each separate auxiliary tract,	3 00
For recording each succeeding auxiliary tract, for the same party, ...	2 00

For any subsequent copy of the foregoing, one-half of the above rates.

Article XXIX.—The Surveyor-General of the territory, or his authorized deputy, shall, when applied to for the record or survey of mineral or auxiliary tracts, file such application at once, and give certificates thereof to the applicants. He shall also have the surveys made as soon as practicable, and issue a plot thereof to the party for whom it is made, on the payment of the fees allowed by this act; and in this article as follows:

For the survey of mineral tracts he shall be allowed for each lineal mile actually run on the ground, including all lines necessary to show the connection that exists between the different tracts claimed by the same party, on the same vein or deposit. Also for those lines or offsets requisite to show the general direction of the vein or deposit, and the distance of the main shaft from at least two of the corners.	$8 00
For the survey of each auxiliary tract, he shall be allowed the same, that is, $8 per lineal mile, unless they are already sectionized by the Government, in which case the law referring to government lands and surveys, shall be applied as in other government lands.	
For marking out the plot or field notes for the parties applying, he shall be allowed for each single tract shown separate, ...	3 00
But if on the same deposit, and in the same locality, several tracts are surveyed for the same parties, then these shall be shown contiguous on the same plat for the sum of	5 00

In addition to the above, the parties for whom such surveys are made, shall pay to the Surveyor-General, or to his deputy, the sum of 20 cents per mile actual travelling done by him in making such survey; calculating the distance from his office to the point of survey—the interrupted portions of different not connected surveys, and the shortest practical route back to his office. They shall also pay 30 cents per mile for the above distances, to defray the expenses of assistants to the Surveyor making the survey. When surveys are made for other parties at the same time, or at any other time, on the same vein or deposit, or on any other distinct vein or deposit, these parties shall also pay the whole of the fees and mileage above enumerated.

ARTICLE XXX.—All mineral and auxiliary tracts, procured by virtue of this act, which may have been abandoned for the space of five years after patents have been issued, shall revert to the U. S., without restitution of the purchase money, and they shall be subject anew to registry as other public lands.

ARTICLE XXXI.—The forfeiture of any mineral tract, shall cause the same of the corresponding auxiliary tracts thereto.

ARTICLE XXXII.—Be it further enacted, That in consideration of the remote and isolated position of the Arizona district—the difficulty of land transportation to it—owing to the want or scarcity of water and grass at convenient distances; the want of sufficient agricultural lands for the production of food; and for the purpose of encouraging and facilitating mining operations in general—there shall be no imposts or taxes collected by this Government for a period of eight years, on any and every article of food, tools and mining materials, and machinery introduced in the country on all that part of the boundary line separating the Republic of Mexico from the United States of America, beginning at the valley and town of Sonoita, near the Ajo mountains, about 135 miles from Fort Yuma, thence easterly along said boundary line to a point due south of the highest peak of the Florida mountains, being distant from the Rio Grande about fifty miles.

HERMAN EHRENBERG.

NEW YORK, *December 1st*, 1859.

As this is a subject of National importance, and at the foundation of the prosperity of many enterprises in the territories, we cheerfully devote space in the Magazine for the suggestions of Mr. Ehrenberg, one of the Pioneers of discovery, whose experience has given him a knowledge of what protection the exploring miner needs. Legislation upon this subject has long been required. As soon as work began upon the veins in California by associated capital, the want of a permanent or secure title was felt. Capitalists were not willing to expend their money in sinking costly shafts, and erecting machinery and buildings, to prove a vein which, by miners' law, might be indefinitely subdivided according to its richness.

The work of exploration and mining in Arizona is much retarded

by this uncertainty of title and secure possession. Except within the limits of a few Mexican grants, of undoubted authenticity, there is no ownership of the minerals for the prospector. The richer or more important his discovery, the less chance has he for undisturbed possession, and by repeated subdivision of "claims" according to the press of adventurers, the inducements to a proper and permanent system of mining are removed.

It has been urged by some, that in order to avoid this evil, it is necessary to institute a new system of division or survey of the mineral lands, to the exclusion of that now established. It is true that the latter, though so perfectly adapted to the broad and level prairies and plains of the West, is ill suited to the narrow ridges and valleys of the Pacific slope, stretching, as they generally do, not from north to south, but north-west and south-east. This is also the prevailing direction of the mineral veins, but the exceptions and variations of direction and depth are numerous. To establish a system of division specially adapted to the wants of the miners, and to decide upon the point where the surveys by one system shall cease and the others commence, is an undertaking of great difficulty, and open to many objections. The necessity for any change is avoided by the plan proposed by Mr. Ehrenberg, who suggests that the prospector who discovers a vein, and marks off upon its course a length of 440 yards, shall have the right of pre-emption and purchase of such quarter sections of land as his claim may intersect, after the surveys have been made in the usual manner. This suggestion may be regarded as the leading and important feature of the plan; no new system of survey is required; the lands may be marked off as usual, and occupied either for mining or agriculture.

Ed. Mining Magazine.

Art. IV.—MANUFACTURE OF COAL OILS.

The Manufacture of Photogenic or Hydro-Carbon Oils from Coal and other Bituminous Substances, capable of supplying Burning Fluids. By Thomas Antisell, M.D. 8vo. pp. 144. New York: D. Appleton & Co. 1859.

The art of extracting illuminating oils from coal and bituminous substances, is one of the most important results of modern chemistry. A few years ago in this country these oils were known only in the laboratory, but now establishments for their production on a large scale, are in operation in various parts of the United States, and capital is being daily invested in the manufacture. Like all arts, this must have its literature, and the want of authentic and precise information upon the methods and products, as well as a connected view of the results obtained by the various experimenters and establishments, has long been felt.

The volume before us is intended to supply this want, and, according to the author, in his preface, is the first published monograph on the art of distilling oils from minerals containing bitumen. It comes to us in the form of a handsome octavo, divided into eight chapters, in which the history of the art; a description and comparison of coals and oil-yielding substances; the general principles of destructive distillation; the character of the products from different substances, and the processes employed, are successively considered, and are followed by remarks on the commercial manufacture; a synoptical resume of patented improvements, and a list of American and foreign patents.

According to the author, the discovery of the production of oils from coal is due to Dr. Clayton in the time of Boyle. The art of purifying the oils, so as to render them suitable for purposes of illumination, was first introduced into France by Selligue, and the first attempt at manufacture in this country was by Solomon Gesner, who operated upon the bituminous shales of Dorchester, New Brunswick.

We extract the following observations upon the products obtained from the destructive distillation of coal:

"Peat, wood, and coal, when subjected to distillation at a red heat, or any temperature sufficiently powerful to destroy

the existing condition of the arrangement of their atoms, afford three distinct classes of products—tar, watery fluid, and gas. The proportion of these to each other, and the exact nature of the several products, depends upon the nature of the crude material and the conditions under which it is distilled. If the decomposition be effected with great rapidity, that is, at a very high red heat, the products will be mostly gaseous—permanently elastic compounds; and the proportion of tar will correspondingly diminish. The quantity of tar depends upon the two conditions stated, and the proportion of photogenic oils derivable therefrom is dependent: 1st, on the constitution of the crude tar; and, 2d, on the temperature at which the second distillation is performed.

"Coal tar is found to contain three classes of substances—acids, alkalies, and neutral substances; of the latter class the tar is mainly composed.

"The most natural mode of describing the substances produced in distillation, would be to take the products in the order in which they appear in the condenser or receiver on the gradual augmentation of the heat applied; this method is accordingly adopted.

"One of the first products which comes over in company with a large amount of water, is a mixture of volatile hydrocarbons, which has received the name of crude naphtha, and when further distilled is known as rectified coal naphtha; this is further purified by mixing it with ten per cent. of concentrated sulphuric acid, agitating, and setting aside for some hours to rest: when the mixture is cold, five per cent. of peroxide of manganese is added, and the upper portion submitted to distillation. This mode of purification has been recommended by the late Prof. Gregory of Edinburgh. The specific gravity of the rectified naphtha is 0.850; it is used extensively as a solvent of caoutchouc, and other allied gums, and also of resins for the preparation of varnish. By repeated purification and fractional distillation, what is termed benzole or benzine by Pelonze and others, is obtained; naphtha being a heterogeneous liquid, made up of several hydro-carbons, of which benzine is the most abundant and important. The numerous applications of which this liquid is susceptible, render it one of the most valuable substitutes for alcohol, ether, turpentine, and other fluids in common use, as a menstruum for dissolving gums, resins, and other commercial products. Its property of

dissolving fat renders it useful for cleansing cloth, leather, &c., from spots of grease, wax, tar, or resin, without any resulting injury to the color, or permanent odor to the fabric.

"The light oils of tar [usually *toluene* and *cumene*] which remain, after rectification, on the surface of the water of the main or condenser, are applied, together with the heavy oils, to the preservation of wood from rotting. The permeation of the pores of the wood is effected by placing the latter in close iron tanks, exhausting the air, and then forcing the oil into the interior of the wood by a pressure of 100 to 150 lbs. to the square inch.

"Both of these oils are highly fluorescent. When pure, they should be colorless and without smell, or with a faintly aromatic odor. Those which smell of creosote always char the wicks, and proportionally with the amount of the impurity. The charring of the wick is consequently a test of an impure oil, or one which contains carbolic acid, as Vohl has distinctly proved. The article sold under the name of double purified coal oil, contains six to seven per cent. of creosote. The oil obtained from paper coal, on sale in the German towns, contains ten to twelve per cent.

"These two oils are, as has been already stated, the valuable photogenic oils, and form the great bulk of the product. It is not possible to state *à priori* how much of each of these are present in any coal oil, as it depends upon the temperature at which they are distilled. These oils commence to come over with the last portions of naphtha (benzole), and they continue to be distilled until the temperature approaches 400°. As the boiling point of toluene is 237°, and that of cumene 314°, the first portions of the light oil will be chiefly toluene and the last portions cumene, and if the distillation be conducted from the outset at a very high temperature, but little toluene may be formed. The lighter the oil, the better is it adapted for burning in lamps; and hence the tar distilled at temperatures not exceeding 320° contains most toluene, while the cumene preponderates when the temperature is rapidly driven up to and sustained near 400°. This result of a high temperature should be attended to in the manufacture.

"Carbolic acid, or creosote, possesses extraordinary antiseptic properties, preventing to a great extent the putrefaction of animal substances. Mr. Calvert has used it as a preservative of bodies for dissection, and also to preserve skins of animals

intended to be stuffed. It has been much employed to produce carbazotic acid, by digesting it with nitric acid, aided by heat—a valuable dye-stuff, which gives magnificent straw-colored yellows on silk and woollen fabrics. The acid is easily made pure at a moderate cost, and greens as well as yellows are produced, which do not fade. Mr. Calvert has introduced this acid into use. Mr. Bell, of Manchester, surgeon, has used carbazotic acid, medicinally as a febrifuge, Mr. Calvert having called his attention to its intense bitter taste, and in the hands of the former, it has proved a valuable remedy for intermittent fever. Mr. Calvert has also applied it as an agent for preserving tanning matters from undergoing any decomposition by exposure to air, the effect of which is to convert the tannin present into sugar and gallic acid, which results in the destruction of the value of the tanning material, since gallic acid has no tanning properties, and tends even to remove the mordants from the fabric. By adding a small quantity of carbolic acid to the extracts of tanning matter, they may be kept and employed by the dyer as a substitute for the crude tanning material." * * *

"*Paraffine* is always produced by the distillation of organic substances at temperatures below a red heat; bituminous substances yield the largest amount of paraffine; but it may be readily obtained by distilling wax with lime. The oil which comes over solidifies, and the paraffine may be obtained by pressure between folds of bibulous paper. In the distillation of coals, it occurs as one of the last products, concentrating itself in the last portions of the heavy oils, which sometimes become so thick as to solidify below 80°. This constitutes what is commonly called "paraphinized oil," in the language of patent processes. The paraffine is separated from the oil by cold, and by a centrifugal apparatus, then melted and run into tin moulds, and afterwards subjected to a cold pressure first, and, finally, pressed when warm, and treated with 50 per cent. of oil of vitriol, which destroys the coloring matter, and, lastly, with a potash lye; it is then again melted and run into moulds."

Dr. A. A. Hayes, of Boston, regards paraffine as a vegetable wax which in distillation of coal is an educt, not a product, as it is capable of being traced back to wax-bearing plants.

In New Bedford candles are made from the cannel coal of Boone County, Ky., which are superior to those of foreign manu-

facture, inasmuch as there is no admixture of other matters, and a fine and regular crystallization is obtained by alternations of sudden and gradual cooling. This coal also affords a thin, light, kerosene oil of superior quality.*

Of bituminous schists, the author observes:

"When bituminous schists are submitted to destructive distillation, besides the production of naphtha occasionally and inflammable gas, there is obtained an empyreumatic oil of a thick consistence. When this tarry oil is submitted to fractional distillation at increasing temperatures, a series of volatile oils is separated, of which the point of ebullition varies between 144° and 540° F." * * * *

"The bituminous schists do not differ in the products of distillation from pure bitumens; the ashy coke, left as a residue, is always more abundant and earthy than in natural bitumens. They have been a long time employed in France, to produce charcoal for decolorizing purposes, due to the fine condition in which the charcoal is left after ignition." * * *

M. Selligue conducts the distillation in cylindrical cast iron retorts, placed vertically; each furnace heats six such cylinders, each of which has the capacity of a cubic metre, and is so constructed that the schists may be introducd by wagons at the upper parts of the cylinder, and the residue drawn off by an iron car run under the lower end. The retorts are so arranged as to economize fuel; the products of distillation are removed from the upper end of the retorts and are condensed in cooled pipes. When the distillation is one-fourth over, the combustible gases produced are turned under the fire-grate, and produce an economy of fuel. The gas is considerable, each cylinder producing 7,500 gallons of gas. Each cubic metre of schist weighs from 1,260 to 1,400 lbs. and yields 90 lbs. of bituminous oil. From one ton of schist, Selligue obtained, in his manufactory, the following products:

1st. 820 lbs. of light oil, specific gravity, 0.760 to .810.
2d. 582 lbs. of mineral oil, adapted to lighting purposes.
3d. 318 lbs. of paraffinized oil, having 14 p. c. of paraffine.
4th. 460 lbs. of tar, or residual pitch.

"The bituminous schists of the United States have not been examined practically with regard to their productiveness in photogenic liquids. The coal schists of the province of

* See Proc. Bost., Soc. Nat. Hist., Sept., 1859.

New Brunswick have been treated by the process patented by A. Gesner in 1854, by which not more than from 40 to 50 gallons of crude oil per ton were obtained. Shortly after the operation was commenced on a large scale, the Albert coal or bitumen was substituted, which being more easily distilled, led to the abandonment of the schists. The large amount of bituminous coal in the United States, will for a long time prevent any attempt being made to distil bituminous schists."

Chapters vii. and viii. of the volume, are devoted to a description of the various methods of conducting the distillations; of the forms of retorts employed, and the purification of the oils. In regard to the proper temperature, it is stated that it must be above that point at which naphtha or benzule is produced, and below that at which naphthalin is formed. Within this range paraffine is produced, and the desirable temperature, therefore, is that between the formation of naphtha and the abundant formation of paraffine. "The range for manufacturing gas lies between 800° and 1,000.° That for the manufacture of oils, terminates where that of gas manufacture begins; and perhaps the most efficient temperature is that which does not exceed 700.°"

To secure the most favorable temperature for the production of the oils, various shapes of retorts have been adopted. The ordinary cast iron gas retorts were much used, but it was soon found that with such retorts the fire must be considerably moderated to avoid the production of gas at the expense of the oils. In many cases the coal or bitumen contains considerable quantities of sulphur or pyrites, which speedily act upon the retorts, and renders their frequent renewal necessary. Clay retorts have been used with success, and, in Scotland, have superseded those of iron.

"Whatever be the material of which the retort is constructed, two conditions are necessary for success; the first is, that the eduction pipe for carrying off the vapors should be attached to the end least heated, and not, as in gas retorts, from the front; the second is, that such pipes should be of sufficient calibre to allow the free discharge of the vapors formed, and thus no great pressure be exerted within the retort, as such prevents the further formation of vapors; in practice, a pipe less than four inches diameter will not deliver vapors readily."

Brick ovens have also been employed, and the author is of the opinion, that in many localities of the Ohio and Illinois and Missouri coal fields, where fire clay is abundant and cast iron expensive, they will be found the most appropriate and economical distilling vessels.

In order to obviate the injury to retorts of iron from the continued application of heat upon the under-surface, revolving retorts have been constructed, with the eduction pipes coincident with the axles or bearings. These have another advantage of keeping the charge of coal or bitumen in motion, thus preventing its being overheated or burned on the walls. This motion, however, has not been found sufficient, and various forms of stirrers have been employed, such as revolving arms or blades, and the Archimedean screw.

In regard to the purity of coal oils, we find the following observations :

"The coal oils, as at present sent into the market, are very impure ; the demand is so great, and disproportioned to the supply, that the manufacturer has neither the necessity nor the time allowed him to re-distil or otherwise purify his secondary products arising from distillation of tar. When, however,f rom a reduced price of animal oil, or any other cause, the demand for oil slackens, then the purification will increase in proportion. In France, where vegetable oils, as rape, camelina, and colza seeds are extensively grown, the oils of schist, as produced by Selligue and others, are sold in a state of great purity ; and in this country, although the public, from motives of economy, may consume coal oils, they will never be used from choice or motives of cleanliness so long as they are sold in their present condition. The object of purification is, to separate the viscous semi-solid, and solid hydro-carbons, which are suspended in the lighter oils, and which, from their containing a large percentage of carbon, cannot be made to burn in ordinary lamps without producing smoke, and which produce this annoyance even when present in no large amount in the more volatile liquids."

On this subject a writer in the *Scientific American* observes :—" Within the past 12 months, the coal oils manufactured in the neighborhood of New York have greatly improved in color, and they now burn with but little smoke. * They are not so durable, however, as the more crude oils formerly sold, because they contain less free carbon, which is the great illu-

minating agent. They are more volatile, do not encrust the lamp-wick so readily, and, although they do not burn so long, they are altogether more pleasant for use. For the brilliancy of its light, no oil—vegetable, mineral or animal—can compare with that obtained from cannel coal; it is a paraffine oil, and its use must continue to increase because of its superior illuminating qualities."

In regard to the localities of manufacture of coal oils in this country, it is stated that they are chiefly confined to the districts where cannel coal can be mined with economy; hence the States of Kentucky, Virginia, Pennsylvania, Ohio and Illinois, include at present all the great centres of manufacture.

"Factories will shortly be established in Missouri, and in every other State where this highly bituminous coal can be obtained. The State of New York is the only exception to the foregoing, the manufacture there being carried on at the seaboard, where the crude mineral (Boghead Coal) can be most cheaply delivered. As it is established at the largest market in the United States, what is overpaid by the use of a costly raw material, is balanced by the reduction of cost of transportation of the refined oil."

At the New York Kerosene Oil Company's works, the oils are both distilled and refined. The crude oil is distilled from Boghead Coal, in towers or pipes, as patented by Luther Atwood in 1858. Those in operation at the date of the publication, held 25 tons of coal, and were lighted by anthracite coal, assisted by pine wood at the commencement. The Company were erecting retorts to contain 100 tons of coal. The daily produce of crude oil was 1,000 gallons.

"The Lucesco Works, in Westmoreland County, Pa., are probably the largest works at present in the country. The capital invested is $120,000. There are now in working order ten large revolving retorts, placed over as many furnaces, each retort having a capacity of two and a half tons. The mineral is distilled for twenty-four hours. The crude oil is rectified at the works in stills having a capacity of 2,000 gallons, each armed with agitators and heated by naked fire; sixteen of these stills are erected. The amount of crude oil produced is almost 6,000 gallons per diem."

The following is an abstract of the author's list of localities, which, it is stated, is necessarily imperfect:

In Pennsylvania there are twelve establishments ; in Ohio, sixteen ; in Virginia, four ; in Kentucky, two ; in New York, three. We mention, in addition, one at South Boston, Mass. ; one at Portland, Maine ; and one at St. Johns, N. B. ; but there are many others which we cannot now specify.

Art. V.—THE WASHOE SILVER MINES.

By Wm. P. Blake.

In the last number of the Magazine we noticed the great discoveries of silver on the eastern side of the Sierra Nevada, in Carson Valley. Just after its publication additional information, embodying many interesting details, was received. This intelligence, though in part already given to the public through the daily papers, is too important to be omitted in the pages of the *Mining Magazine*, which it is intended shall be a record, as far as possible, of the progress of mining discoveries.

The principal vein now being worked is just over the California line, in the Territory of Utah, and is about 175 miles distant from Sacramento City, and on the travelled route to the Great Salt Lake. The region is nearly due east from Marysville, Grass Valley, and the sources of the American River. It is elevated and pertains to the Great Basin, though there are, all along the mountains, a great number of basins or valleys, with lakes, from which there are no outlets. A good wagon road has been constructed over the Sierra Nevada from Placerville to the Valley, at a cost of $50,000, which was expended by the counties of El Dorado and Sacramento. There is also a line of telegraph.

The mines were discovered by a man named Comstock, who sold out his claims to different parties for small amounts. The correspondent of the *New York Times*, who is personally known to us, and upon whose statements we fully rely, writes as follows under date of 5th November :

"One company, known as the Walsh company, are getting out at the rate of two tons a day of the silver ore, besides several tons of the quartz stripped from the vein, which has been yielding, by the Mexican 'arastra' process, over $400 per day ; but the gold is lessening as they go down, and gradually

merging into silver. The vein has been traced over a thousand feet. The Walsh Company have 1,400 feet ; next comes Bryant & Raymond, who own 50 feet, for which they paid $400 per foot, from which they have already shipped down to this place about 13 tons ore, worth, by actual demonstration, over $3,000 per ton. From the Walsh vein there has been received about 28 tons, and 12 tons more out and ready to come down. This ore goes all the way from $2,500 to $6,000 per ton, containing both gold and silver, but silver principally. These facts I *know* from the best authority, or ought to, as I have received here, in connection with other parties, the quantity above mentioned, and for the value of it, have the assays and tests of the United States Branch Mint. The proper furnaces are being built, and within a week the ore will be smelted on a large scale. What ore we have on hand, will, doubtless, turn out over $200,000.

"It is estimated that there are still as rich veins and as extensive 'leads' of ore as any yet discovered, to be found in the vicinity. In fact, Comstock, the original discoverer, told me yesterday he knew where there was plenty more of the same sort, which he would bring in market in the spring, and evidently considered that he held his fortune in reserve, which accounts, perhaps, for his seeming indifference to the small results to himself of his discovery thus far.

"The roads to the Washoe Mines will be closed by snow by the 1st of December, and no more ore can be hauled before the 1st of March ; but the work of getting it out will not be interrupted in the least, and by spring an enormous amount will undoubtedly be ready for shipment. The ore is hauled to Sacramento in wagons, in tight boxes and canvas bags, and shipped down to this place."

The following details are extracted from the San Francisco *Bulletin :*

"Mr. F. J. Hughes arrived in this city last night from the new mining region in Washoe Valley.

"Mr. Hughes went to Virginiatown, the locality of the richest discoveries, in June last, and remained there until the close of last week, so that his opportunities of observation have been ample. The existence of silver in that region was discovered by three men who were working a good claim in Six-mile canon, in June of the present year. Following their surface diggings, they at length struck the gold lead, consisting

of a black soil without lustre, so rich that portions of it yielded eighty dollars to the pan. They found a pocket, as it is called, filled with black metal, from which they made $100 per day with a rocker. A number of Mexican miners from Sonora examined the tailings or refuse dirt, and informed the miners that they were throwing away two dollars of silver for each one of gold that they collected. A company of three or four Mexicans commenced working these "tailings" for the silver, and for some time collected from $300 to $400 per day.

"About two months ago Judge Walsh took one ton of the black metal, in which the silver occurred, to San Francisco, in order to procure a reliable assay. The result was from $900 to $5,000 per ton, according to the parts of the mine from which the specimens were taken. It is a remarkable property of 'the black metal,' that it decomposes and becomes soft from exposure, to such a degree, that it can even be crushed between the fingers. The claim had in the mean time been divided into six shares, two to each of the original parties. Comstock sold his for $5,500, and McLaughlin his portion for $5,000. Riley is now the only one of the original parties interested in the lead, and he has refused—so Mr. Hughes says—$40,000 for his share. Judge Walsh owns two-sixths, and is said to have been offered $60,000 for half his interest.

"Mr. Hughes has with him a mass of silver mixed with gold, weighing 47 ounces, valued at $2 per ounce. This bar was obtained from one arroba, or 25 pounds of the tailings before spoken of. Could this be taken as a fair sample of the whole, it would indicate the astonishing result of a mass of refuse dirt, from which the gold had been extracted by the ordinary process, worth four dollars to the pound. The ledge in the Comstock claim has two leads of gold and one of silver ore. The gold rock has been proved by the ordinary test to be worth from $500 to $2,500 per ton. The silver lead consists of the black metal, which is stated to produce $5,000 to the ton, in the proportion of 46 of silver to 4 of gold. The gold leads are from five to nine feet thick, and the dip of the gold-bearing rock is about 80 degrees, or nearly perpendicular. The entire ledge is between 15 and 20 feet wide. The silver vein is from 6 to 24 inches wide. The deposits are at Virginiatown, which is twenty miles from Carson Valley, fifteen from Carson City, and about 160 miles from Sacramento. There is a ledge of gold rock near Washoe Lake, which is said to have yielded $2,100 in gold to the ton.

"More than twenty other veins have been opened in the vicinity, and are now in the process of development. It is thought that they extend all the way from Honey Lake to Walker River. The prospectings generally reveal gold on the surface; the silver appears eight or ten feet below. The most magnificent deposit of gold ever discovered in this continent or in the world, is represented to have been opened at Gold Hill, in a canon, or rather valley, one and a half mile from Virginiatown. The hill is isolated from the mountain spurs, to which it probably once belonged, and is properly a mound, about 60 feet high, 5,000 feet long by 2,000 feet wide. It is traversed by veins of auriferous quartz, partly decomposed, yielding from $500 to $2,500 to the ton.

"There are now eighteen arastras in operation in Virginia town, and eight or nine at Gold Hill.

"The nearest timber suitable for lumbering purposes is fifteen miles from the mines, and the mines which can be relied upon for a supply are twenty-five miles distant. The price of lumber at Virginiatown is $50 per M. The habits of the people are necessarily nomadic and sporadic. They live in tents—as many of them as can secure that accommodation; those who cannot, sleep in haystacks. When meals can be had, they are furnished at the reasonable price of 75c. each.

"About eighty tons of silver have already been sent to San Francisco, or are on the way; and Mr. Hughes passed almost a hundred teams going out with provisions and general supplies. The price of freight has been raised to 10c. per lb., or $200 per ton, from Placerville; but the silver ore is brought this way for half that rate. The rush to the mines is so great that a daily line has been arranged. On the day on which he arrived at Placerville, six full stage loads of passengers had been engaged for the next trip.

"Mr. Hughes states that ten feet claims are selling at from $2,500 to $3,000 cash."

During the month of October, silver to the amount of $38,123. 58 was deposited at the San Francisco Mint, the greater part of which was from the new mines.

A private letter from Mr. Guido Kustel, assayer and smelter, states, that he smelted 1,200 pounds of the ore, and got out silver at the rate of $4,600 to the ton. From ore

which yielded some Mexican smelters in Washoe Valley 48 ounces, he obtained 500 ounces in two days without a furnace. The average yield of the ore is said to be about 1,500 ounces. Some of the ore has been shipped to Europe, but the owners generally prefer California smelting. The actual cash sales of small interests in the original vein since 1st September, are said to amount to $60,000.

There are reports that rich and large veins of silver ore have been discovered east and south of Genoa, and near Mono Lake. Of the existence of other veins there can be little doubt; indeed it is probable that this is but the commencement of a series of discoveries, that will soon render the eastern slopes of the Sierra Nevada, and the countless valleys of that great mountain plateau, the field of mining operations on the grandest scale, producing results that will compare favorably with, if they do not exceed, those of the richest mines of Mexico or South America.

The region is one where metamorphism of the rocks has been most intense and complete, and where eruptive porphyries, not unlike those of the Mexican plateau, abound. It is probable that these extensive silver-bearing veins will be found to be coincident in direction with belts of limestone, and near them. A belt of limestone, probably of the age of the Carboniferous, is found in connection with quartzites, or metamorphosed sandstones, at the southern end of the Sierra Nevada on the eastern slopes, and the formation is, without doubt, extended northwards through the region of Owens River and Lake, Mono Lake, and the Walker River country to Carson Valley, and beyond. This belt of country, extending over five degrees of latitude, and about four hundred miles in length, should be immediately explored. We venture to affirm that it will be found rich in minerals, and in silver-bearing veins. The whole region of the Great Basin—that vast expanse of mountain ridges and valleys—is also one of the most promising fields for exploration, though at present none but the precious metals can be profitably mined there. The rich gold vein of Armagosa, on the Salt Lake trail from Los Angeles*, is an indication of what we may expect to find throughout that great area, which, except along a few lines, is as yet almost geographically unknown.

* See Author's Report of a Geological Reconnaissance in California, p. 298.

MINING AND SCIENTIFIC INTELLIGENCE.

GEOLOGY.

*Report of Captain J. H. Simpson, Corps of Topographical Engineers, U. S. A., of Reconnaissances, &c., in the Territory of Utah. With a Map of Wagon Routes in Utah.**

The explorations, of which this volume is a Report, were made during the months of August, September, and October, 1858, and resulted in important additions to our knowledge of the topography and natural history of Utah Territory; the opening of a new wagon route from Camp Floyd to Fort Bridger, and the selection of a better and shorter route for the great northern emigration and mails to California over the Salt Lake desert.

The desert is described as level as a floor, and, in spots, perfectly smooth and divested of every vestige of vegetation. The soil is clay, slightly intermixed with fine sand, and packs hard. Its general appearance is said to be that of a baked surface, checkered by cracks, with now and then a patch smooth and denuded, looking like a polished clay floor. Light sand could be seen at a distance drifting in the wind. The descriptions bring the aspect of the Colorado desert to mind, and, in fact, both deserts are similarly formed, and of lacustrine origin.

In regard to the routes between St. Louis and San Francisco, Captain S. observes :—" I have already been over, all the way through to California, and this in such a direct course as in connection with the Fort Laramie route, or that of Lieut. Bryan, via Fort Kearney to Fort Bridger; and the new one I have opened thence to Camp Floyd, might, in all probability, furnish a route all the way through from St. Louis to San Francisco, which would be 500 miles shorter than the present post route between those points by the way of Fort Smith, through northern Texas and Arizona."

Appendix " A.," consists of the Preliminary Geological Report on the country between Fort Bridger and Camp Floyd and the vicinity, by H. Englemann, geologist of the party. This region is said to extend from the western rim of the Green River Basin over

* 35 Cong., 2d Sess. Senate. Ex. Doc. No. 40, 8vo., pp. 84.

the Washitah Mountains to the eastern part of the Great Basin, and to comprise strata of the Carboniferous, Cretaceous, and Tertiary periods, together with a great variety of igneous rocks. The formations of Green River Basin are described as marine Tertiary, and consist of three series of strata. The first, or upper, estimated to be from 200 to 300 feet thick, consists of coarse green sandstones, arenaceous and argillaceous shales, and calcareous slates. The second series has a thickness (estimated) of 100 feet, and is more calcareous, consisting of slaty calcareous sandstones, and of limestones partly oolitic, and fetid. The limestones are quarried for building purposes at Fort Bridger. The third series, with a thickness of near 200 feet, is generally formed of white, or light colored, fine grained sandstones.

This group of strata "overlies, unconformably, strata of Cretaceous age, and must, therefore, belong either to the later part of the Cretaceous, or to the Tertiary period."

The Cretaceous formation was found developed on the eastern slope of the Washita Mountains, and is said to contain a large quantity of coal, which comes to the surface at several points. The presence of beds of coal in this formation, is not only of great scientific interest, but of manifest importance to the country. Mr. Englemann cites the various localities of coal west of the true Carboniferous coal-field of Missouri and Kansas, at which coal has been observed, and is disposed to regard them all as Cretaceous or Tertiary. He omits, however, to note the fact that coal seams have been found in the true coal measures of the Rocky Mountains, where, also, a good anthracite occurs, as shown by the writer. The Carboniferous formation is developed throughout a portion of the region Mr. Englemann examined. It is said to extend westward as far as the explorations were carried—to Pass Shortcut—to the exclusion of any other stratified rocks of older than Quaternary age. Fragments of coal were found in an affluent of the Timpanogos, which cuts through the Carboniferous rocks, and some masses of shale with particles of "anthracite;" but this coal is regarded as Cretaceous. No coal was found in place. We extract the following interesting descriptions of remarkable mineral springs:—

"Nearly the whole portion of Round prairie, on the north-west side of the river, is formed of horizontal strata of calcareous tufa, in some places 15 to 20 feet high from the creek, and covering an area of about four square miles. Most of the springs have the shape of conical

tumuli of various heights, with a circular or oval opening on top, and an oven-shaped cavity inside, wider at the base than near the river. Their number is very great, if we count all the small ones, and the diameter of their openings varies from a few inches to 30 feet. One of the most beautiful, forms a basin 30 feet long, 12 feet wide, and 18 feet deep, in which the water reaches to one foot and a-half, of the rim * * * * * On the western plateau is the highest spring; its cone is about 60 feet high, 100 feet wide on top, and 200 at the base. The opening upon the top of this spring is only 12 or 15 feet wide, partly covered over with calcareous scum deposited over fucoid plants which float on the water, and on top of which grass was found growing. The water was found 10 feet deep, and 107° Fahrenheit warm; it flows freely over the rim of the cone, and disappears at the base in the pumice-like tufa, which it has deposited, and the swampy ground around.

The region appears, from the report, to be peculiarly barren of useful minerals, none having been observed, except the magnetic iron ore which Capt. Stansbury noticed near the north shore of Salt Lake. It was rumored that lead and silver mines had been found near the southern line of the territory. We do not doubt, however, that explorations in detail will bring many important localities of valuable ores and minerals to light.

Geology and Minerals of New Zealand.—A survey of the Auckland district, New Zealand, has recently been completed by Dr. Ferdinand Hockstetter. He is of the opinion that the argillaceous silicious rocks will be found to correspond in age to the oldest Silurian strata of Europe. These rocks have a wide extent in the province, and contain all the metalliferous veins hitherto discovered there. To these rocks belong the copper pyrites, which has been worked for some time at the Kawau and Great Barrier, the manganese at Waiheki, and the gold-bearing quartz at Coromandel.

The secondary formation is characterized by ammonites and belemnites. The older Tertiary formation contains extensive seams of brown coal, which are developed both in the northern and middle islands. The average thickness of the Drury seam is about six feet. A company, called the Waihoihoi Mining and Coal Company, has already been formed for commencing operations on the coal. At Kupakupa a seam over 15 feet in thickness is partially exposed.

The fossil plants found with this coal are chiefly leaves of dicotyledones. Dr. Hockstetter remarks, that he cannot see any reason

why this kind of coal should not be used in New Zealand for the same purposes as a similar brown coal is extensively applied in various parts of Europe, and particularly in Germany, where it supplies the fuel for manufactures of all kinds, for locomotives and steamers, and for domestic purposes. He was perfectly familiar with this kind of coal, and could assure the people of Auckland that their brown coal was quite as good as that which is used in Germany for the purposes mentioned. He would strongly recommend, that any company which may be formed for the purpose of working the coal, should at the same time establish potteries for the manufacture of earthenware. Remarkably suitable clays, of every necessary variety, have been shown to exist in the immediate neighborhood of the coal fields, by the government borings. By the establishment of such works the value of the coal would be made apparent to everybody, and the manufacture itself, if properly conducted, could not fail to be remunerative. It may be interesting to know that the far-famed "Bohemian porcelain" is burnt by means of brown coal, from a seam of, in some places, 90 feet thickness.—*Abstract from London Mining Journal.*

Preliminary Report on the Geology of Vermont, by Edward Hitchcock, State Geologist. 8vo., pp. 16. October, 1859.—This Report is accompanied by a Report of the Committee of the Vermont Senate upon the portion of the Governor's Message relating to the Geological Survey. From this it appears that an act providing for a geological survey of the State, was passed by the Legislature as early as the year 1844. By virtue of this act, Gov. Slade appointed Prof. Charles B. Adams, who entered upon his duties in the spring of 1845, and who subsequently made four annual reports, which were printed and distributed among the people. The Legislature, after this, failing to make an appropriation, the work was suspended. A resolution providing for the collection of the field notes and specimens, to be deposited in the State House, was passed in 1848, and the labor contemplated in this resolution was committed to Prof. Zadoc Thompson. Before a final report could be compiled, Prof. Adams died, and his field notes being in hieroglyphics, were found by Prof. Thompson comparatively useless. In October, 1853, an act was passed for completing the survey, and the work was placed in charge of Prof. Thompson, who also died, leaving the work unfinished. In 1856 Prof. Edward Hitchcock was appointed State Geologist, and commenced the work of exploration in the spring of 1857,

aided by Edward Hitchcock, Jr., Charles H. Hitchcock, and Albert D. Hager. The completion of the final report is now announced. It consists of a joint Report on the Scientific Geology; a Report on the Economical Geology, by A. D. Hager; a Report on the Chemistry of the Survey, by Charles H. Hitchcock; catalogue of 2,800 specimens of rocks, 370 specimens of minerals, and several hundred specimens of organic remains; and, finally, the Report of Rev. S. R. Hall on the Agricultural Geology of the State. It is thought that the Report will make a quarto volume of 500 or 600 pages, with from 20 to 25 plates. An appropriation to defray the expenses of publication is required.

Geology of South Carolina.—We regret to learn that the Legislature of South Carolina at its last session, just terminated, failed to make the customary appropriation for the continuance of the Geological Survey of the State under the able direction of Oscar W. Lieber, Esq. The Annual Reports of progress of the Survey for three years past have given great satisfaction, and added largely to our knowledge of the resources of the State. It is a matter of surprise and regret that the Legislature of South Carolina should allow a work of such manifest importance, so well commenced, and so faithfully prosecuted, to cease for want of the small sum necessary to carry it on.

Geological Survey of Georgia.—His Excellency Gov. Brown, in his late Message, repeated a recommendation made in his previous Message, that provision be made for a Geological and Mineral Survey of the State. This recommendation was hailed with pleasure by a large majority of the intelligent citizens of the mineral districts of the State, and a bill providing for the appointment of a State Geologist, &c., was introduced during the session of the Legislature, but was not passed.

The importance and value of such a survey to the purely agricultural counties of the State, as well as to those rich in mineral veins, does not appear to be understood. Aside, however, from the immediate economic value of the work, the results in a scientific point of view should alone be sufficient to induce the necessary appropriations.

IRON.

Welding Steel.—English cast steel, as is well known, is difficult to weld, on account of its great fusibility. In Wirtemberg it is placed in the midst of a powder composed of eight parts of sulphate of barytes, two parts of unvitrified salt, and two parts of peroxyde of manganese, which facilitates the welding of the steel, and replaces the sand ordinarily employed. This mixture is cheap, and allows the steel to be heated to a very elevated temperature without injury. —*Dingler, Polytechnisches Jour.*, T. clii. p. 74.

The Steel Trade.—Each week additional proofs are given that both steel consumers and the public fully appreciate the importance of Mr. Bessemer's inventions; and there now appears to be every prospect of the Bessemer steel becoming the greatest favorite in the market. A few weeks since we recorded the favorable opinion given in their report by the officers intrusted with the War Department Experiments upon Iron, and we learn from good authority that further experiments at Woolwich have more than confirmed the statement already published. It is, we think, probable that one of the greatest difficulties which Mr. Bessemer has to contend with in getting his steel immediately introduced, arises from the appearance being different, and in many instances opposite, to that of similar metal manufactured by other processes. Thus, it is usually considered that iron without the appearance of fibre cannot be tough, yet a bar of the Bessemer metal, manufactured from ordinary English coke iron, and presenting such a grain that an experienced iron-master had no hesitation in pronouncing it to be "frightfully cold-short," was so tough that a 3-inch square bar could be doubled together without showing a flaw on the outer side, which was reduced by the strain to 2¼ inches in width. It is, therefore, evident that the Bessemer metal is entitled to the good opinion of steel and iron consumers, even upon this evidence of its value alone; and recent trials at Woolwich have brought forward another fact of vast importance to consumers—the amount of forging required is insignificant as compared with other metal; if a 3-inch ingot be forged down to 2½ inches, it will bear twice the tension strain (the unforged ingot being equal to the best iron of other makes), and by further reducing it to 2 inches the maximum is attained, and additional forging appears to have no effect upon it. When manufactured into boiler-plates, the Bessemer metal throws best Low Moor altogether into the shade, a section of ¼ inch in Bessemer plate 1 inch wide, bearing a greater strain than ⅜ inch Low Moor 1¼ inch wide, and a less strain than ⅜ inch Low Moor 1⅜ wide, whilst the Bessemer plate is so tough that it may be doubled together and hammered close without

showing a flaw. The new metal is now fairly in the market, and large quantities are already supplied weekly, the prices being—Best tilted tool steel, ½ inch and upwards, in square, round, oval, octagon, and flat bars, 44s. per cwt.; ⅜ ditto, 46s.; 5-16th ditto, 54s.; ¼ ditto, 60s.; and 3-16ths ditto, 75s. Direct cast-steel bars, 1½ inch, 25s.; above ½ inch, 27s.; ½ inch, 28s.; ⅜ inch, 30s.; 5-16th inch, 32s.; and ¼ inch, 37s. The extras are, on octagon 2s., and on round and oval 3s. per cwt. for inch and smaller sizes of direct cast-steel. Cast-steel boiler-plates, up to 3 cwts., 25s.; sheets, 8 to 14 wire gauge, 25s.; piston-rods, shafting, &c., 25s.; and ingots, 56 lbs. to 20 cwts., 20s. per cwt.—*London Mining Journal, Oct.* 29.

Alloy of Tungsten and Iron.—Mr. Robert Mushet has patented an invention (No. 690) being the eleventh in 1859, and since which he has petitioned for nine other patents, which consists in an alloy of tungsten, iron, and manganese, made by melting together reduced or deoxidized wolfram or tungsten ore, or oxide of tungsten, and a metallic compound of iron and manganese, containing carbon, such as the white crystalline iron or pig metal made in Rhenish Prussia, and called "spiegel eisen."—*London Mining Journal, Oct.* 22.

Strength of Foreign Iron Bars and Plates.—In the mechanical section of the British Association a paper was read by Prof. Macquorn, giving an abstract of a set of experiments conducted by Napier & Son, the great engineers of Glasgow, to test the strength of iron and steel bars and plates. The following are tables giving the results of their experiments with loads applied gradually:

TABLE A—IRON BARS.

Districts.	Tenacity in lbs. per sq. in.
Yorkshire, strongest	62,886
Yorkshire, weakest	60,075
Yorkshire, forged	66,392
Staffordshire, strongest	62,231
Staffordshire, weakest	56,715
West of Scotland, strongest	64,795
West of Scotland, weakest	65,655
Sweden, strongest	48,232
Sweden, weakest	47,855
Russia, strongest	56,805
Russia, weakest	49,564

TABLE B—IRON PLATES.

Yorkshire, strongest lengthwise	56,005
Yorkshire, weakest	52,000
Yorkshire, strongest crosswise	50,515
Yorkshire, weakest crosswise	46,221

TABLE C—STEEL BARS.

Steel for tools, rivets, &c., strongest	132,909
Do. do. weakest	101,151
Steel for other purposes, strongest	92,015
Do. do. weakest	71,486

TABLE D—STEEL PLATES.

Strongest lengthwise	94,289
Weakest lengthwise	75,594
Strongest crosswise	96,308
Weakest crosswise	69,082

NOTE.—The strongest lengthwise is the weaker, crosswise, and *vice versa.*

COPPER.

Lake Superior Mines.—The following are extracts from the Agent's report, on the Minnesota, Rockland, and Superior mines, for the month of October:

Minnesota Mine.—Product for October, 152 tons. At the sixty-fathom level, and near the bottom of No. 8 shaft, we have a mass of about 30 tons now in progress of cutting up. The last 15 feet of driving here is uncovering another mass, about two feet thick, and dipping east. This shaft is now in readiness for sinking to the seventy-fathom level. No. 5 shaft is down to the 70, and preparing to sink to the 80. West of this shaft is good stoping ground. On the east it is connected with No. 4 shaft, and this block of ground is good for mass and barrel work. We are now cutting a mass in this drift of about 10 tons, with several other smaller masses. No. 4 shaft is sunk to the ninety-fathom level, carrying all through a good vein; and in drifting both east and west, the vein is as rich as in sinking. West of No. 4, at the 80, is good stoping ground, yielding mass, barrel and stamp-work. The ninety-fathom level is drifted west 45 feet from No. 3, all the distance exposing masses of copper, which look very rich. One mass is now cutting at this point of about 60 tons, and in all there cannot be less than 100 tons in sight here. East of No. 3 is also good ground, yielding mass and barrel work, and this shaft is now preparing for sinking to the 100-fathom level, with good prospects. No. 1 shaft is down to the 90, and the drifts from it both east and west are producing small masses and barrel-work. No. 2 shaft is also at ninety-fathom level.

In the sixty-fathom level, east of No. 6, we are opening good stoping ground. In the fifty-fathom, east of No. 10, the ground is soft for drifting and rich copper. The twenty-fathom, east of No. 10, is connected with No. 9 shaft, and opens a good block of ground. The ten-fathom, east of No. 9, is drifted about 200 feet, and considerable stoping had been done at this point with good success. The eastern part of the mine will be worked stronger in future, as No. 10 will be in full operation, and can keep the dirt

free. No. 8 shaft has heretofore been kept clear by horse-power, but at present is connected to and worked by No. 6 engine.

The conglomerate workings between Nos. 4 and 5 shafts are yielding well, about 20 tons being taken from this point during the last month.

These statements show a decided improvement in the underground appearances since my last report; and as we are now getting a good vein, with a handsome show of mass copper at so many different points in the mine, we can hardly fail to increase our future production.

Rockland Mine.—Herewith I hand you return for October, 41 tons. This mine continues to show well for copper. We have a fair vein in the forty-fathom level, which is opened some 700 feet in extent, not more than one-third of which is as yet stoped out. No. 3 shaft is down to the fifty-fathom level, and is now preparing for drifting—in sinking the last lift, the vein is promising, showing mass copper. No. 1 shaft is 50 feet below the forty-fathom level, and the vein to that depth is rich and productive. No. 4 shaft is also below the forty-fathom level, and improves in sinking. We should have had a larger return from the stamps this month, but the breaking of the axle, heretofore reported, somewhat delayed us—all is now, however, in good working order, and we shall run them during the entire Winter.

Superior Mine.—The vein at this mine has improved somewhat since my last advices, having more barrel work, and a stamp fine lode —it is some twenty inches thick at the end of the level, carrying sheet copper of considerable size. The work is being carried on at comparatively small expense, and we expect still further improvement during the winter, as we get further west, and more in the settled rock of the bluff. Copper produced in October, 1,434 lbs.

Copper Shipments from Portage Lake.—The *Detroit Tribune* furnishes the following statement of copper shipments from Portage Lake district the past season:

Quincy	850 tons	630 lbs.
Pewabic	813 "	1,556 "
Franklin	218 "	597 "
Isle Royale	260 "	518 "
Portage	9 "	503 "
Total amount	1,804	2,151

This is an increase of 500 tons on last year's shipment. The shipment from the Ontonagon district will raise the amount to 4,325 tons, and *The Tribune* estimates that the shipments from other districts will swell the total amount of the produce of the mines this year to about 5,500 tons. The value of this copper is between $2,250,000 and $2,500,000.

The *Lake Superior Miner* of November 29th, gives the following annual statement of the amount of copper shipped from Ontonagon:

Herewith we present the readers of the *Miner* with our usual annual statement of the copper exports from this port, as compiled from the shipping books of Messrs. Willard & Day:

MINES.	*No. of Masses.*	*Weight.*		*No. of Barrels.*	*Weight.*		TOTAL.	
		tons.	lbs.		tons.	lbs.	tons.	lbs.
Minnesota.....	1,808	1,004	130	1,992	660	1,127	1,664	1,257
Rockland......	249	175	98	489	189	583	364	681
National.......	297	217	1,754	245	96	409	314	263
Adventure.....	13	13	1,309	331	129	1,981	143	1,290
Ogima.........	25	8	541	79	28	1,306	36	1,847
Everg'n Bluff	20	6	1,909	55	21	623	28	532
Norwich,......	23	11	615	26	11	644	22	1,259
Aztec..........	9	1	1,828	44	14	230	16	158
Nebraska.......	12	4	1,031	15	6	1,994	11	1,025
Toltec..........	4	2	1,448	15	6	382	10	1,830
Bohemian......	2	–	1,088	13	5	1,326	6	414
Ridge...........	1	1	247	69	28	498	29	745
Mass...........	15	3	1,457	23	9	211	12	1,668
Superior.......	—	–	......	4	1	876	1	876
Hamilton......	—	–	......	2	–	1,486	–	1,486
Total amount shipped from the district,							2,663	1,321

This shows a decrease of thirteen tons in the aggregate shipments of last year, which is less than we supposed it would be. The main falling off is in the Minnesota, which last year shipped 1,911 tons; yet her loss of 247 tons is nearly compensated by the gain in product of National and Rockland, the former shipping 104 tons over their exports in 1858.

The greatest *percentage* decrease is in Toltec, which last year shipped 31 tons 826 lbs.

The largest per centage increase—where any was shipped last year—is in Evergreen Bluff, the last year's shipments of which were only 5 tons 1,614 lbs.

The Ogima has just held its own, while the gain at Adventure of 56 tons, more than compensates for the loss of 40 tons at the Ridge, and 15 tons at the Mass.

Nebraska shows a diminution in shipment of some 4 tons, which however is more than counterbalanced by the amount of copper exposed in the No. 2 shaft, but which could not be raised time enough for shipment this fall.

Aztec, which last year shipped only 5 tons 1,746 pounds, this year sends off 16 tons, with a very small additional outlay by the Company. We are glad to learn that additional mining force is to be employed at this mine for driving on the main lode in their No. 2 (eastern) adit level.

We are now able to report the October product of the

Minnesota mine at	151 tons	1,862 lbs.
National mine	50 "	
Rockland	40 "	1,836 "
Superior		1,433 "

From the *Mining Gazette* of the 19th instant, we learn that the largest mass ever shipped from that district, was sent by the last *Northern Light*, from the Quincy mine, weighing 8,140 pounds!

That the October product of the Pewabic was not 80 tons, as previously stated, but over *one hundred tons*, as follows:

Kiln copper	55 tons	202 lbs.
Stamp	45 "	455 "
Total product	100 "	657 "

That two new heads of Ball's Stamps are now being erected, under the personal supervision of the inventor, who is also making valuable improvements on the motive power of the old battery.

That the shipments from the Pewabic the past season "are probably near nine hundred tons."

From another source we learn that the

Pewabic shipments were about	800 tons.
Franklin about	200 "
Isle Royale	250 "

and that the total shipments of the Quincy mine from its opening to the present time, is about 800 tons of barrel and mass copper; what the Quincy shipped this season, our informant does not state.

Adventure Mining Company.—The Lake Superior Journal of the 9th of November says:—

We have before us the annual report of the Adventure Mining Co., (of which Thomas W. Buzzo is the agent), showing quite an encouraging state of affairs. The exhibit shows a surplus of $4,404, against a deficit of $22,000 last year, and a net gain actual earnings of $6,743 in the eleven last months. Masses and barrel work, which had disappeared in 1858, are again met with in considerable quantities, and the condition of the mine, the directors say, is manifestly improving under their newly-appointed and very efficient agent, Mr. Thomas W. Buzzo. The Directors are C. G. Hussey, Thomas W. Howe, James B. Murray, James M. Cooper, of Pittsburgh, and D. S. Cash, of Ontonagon.

Important Discovery of Copper Ore in Canada.—An extensive bed of copper ore has recently been opened at Acton, C. E., and has

yielded some hundreds of tons of ore at little expense for mining. The ore is the vitreous or the variegated sulphuret, contains a little silver, and averages from 30 to 40 per cent. of copper. Over $60,000 worth was raised in a short time. It forms a bed or lenticular mass in the limestone, and is intimately mixed with a sort of chert or fine-grained quartz, and with the limestone. The deposit belongs to a belt of magnesian limestones of the Hudson River group, the cupriferous character of which was long since pointed out by the Canada Geological Commission. The ores of Megantic, which were described, belong to the same series. This new locality has been carefully examined by the Commission, and we look for an interesting description of it in the forthcoming Report.

Terra Nova Mining Company.—This is the title of an organization, which, according to the prospectus, dated Boston, Oct. 25th, 1859, has been engaged during the past five years in a series of explorations for mineral deposits in the island of Newfoundland. Two large and valuable veins of copper are said to have been discovered on the northeast coast of Newfoundland, "in the immediate vicinity of which vessels of the largest class can safely load."

According to the Report of Mr. H. H. Sheldon; "The mine, so called, is a most remarkable and valuable deposit, presenting a stratified mass of ores between beds of clay slate, and various altered rocks, which constitute the formation. The substances composing the workable mass are copper and iron pyrites, with arsenical pyrites, and perhaps ores of other metals."

The specimens of the ore received by the Editor are chiefly iron pyrites, with a low per cent. of copper. Whether they represent the average of the deposit was not stated.

GOLD.

The Gold Placers of Vermont.—The following interesting statements regarding the Vermont Gold Mines were received in a letter from H. D. Hager, Esq., of the Vermont Geological Survey:—

Gold was first washed out in Vermont in 1855; there was considerable prospecting, but most of the gold was obtained in the town of Plymouth. The whole amount mined in the State during that

season was seven hundred dollars worth, of which about five hundred dollars was from Plymouth. This gold averaged twenty-three and a quarter carats fine, worth 99½ cents a pennyweight. In 1856 and '57, little was done at Gold mining in the State. In 1848, Mr. Hankerson returned to Plymouth, and during the fall took out $400 worth of gold in a space less than two rods square. Gold was washed at other points, but little was obtained. It is probable that the yield for this year (1858) in all the diggings, including those at Worcester, was $600. This year, 1859, the excitement at Plymouth Mines was very great for a short time, and considerable Gold was washed, more than in preceding years. About seven thousand dollars' worth has been obtained. The greatest yield was $62 50 in one day to three men; but the average, taking the whole time, is very low, and not easily obtained.

This Gold is found in the talcose slate formation, (so called,) and in Plymouth is most abundant at or near the junction of the talcose slate with soapstone and serpentine. Bitter spar is very abundant in the soapstone, and quartz in the talcose slate, interstratified and in concretionary masses, rarely in veins. The larger pieces of gold usually have quartz in them, but there are cases where no quartz is found with the gold. In a few instances gold has been seen in the *slate*, passing through it in small veins. It is sometimes abundant in the decomposed steatite or dolomite, but is in very small grains. That obtained in the deposits is quite coarse, and like that found in the hill deposits of California.

Further particulars will appear in the forthcoming Report on the Geology of the State.

The Bellows Falls *Times* of November 11th says:—

Messrs. Graves and Beals of Springfield, Mass., bought a claim of forty-five rods, for which they paid $225. They commenced digging in July, and up to Oct. 23d, they had taken out $1,700. The most taken in one day was $70, which is the largest sum yet taken in those diggings by any miner in one day. A part of the time they had one hand to help them. It will be seen, therefore, that the close of the mining season presents a favorable record, and the number of miners there the next season will doubtless be much increased.

Glade Gold Mines.—We have received a pamphlet containing the Reports of Prof. Emmons and Prof. Darby, upon the Glade Gold Mines, in Cass County, Georgia. This is a rich mining property, which has been offered for sale in New York. It consists of eight forty-acre lots, traversed by several veins which are minutely de-

scribed by Prof. Emmons. Some of these bear coarse gold in quartz, and have afforded many rich masses. Prof. Emmons concludes that the gold extends along the veins through the whole property, and is not concentrated in pockets alone. From 2,800 to 3,000 dwts. are said to have been taken out in nuggets in testing the mines during the past summer.

Tetradymite or Bornite at the Glade Mines.—Among the specimens of rich gold quartz, submitted to the Editor by Rev. B. F. King, one of the proprietors, several masses containing telluret of bismuth, were observed. The mineral greatly resembles that from the remarkable vein in the Chestatee river near Dahlonega, which proves to be *bornite.* This is the second locality observed in the State.

Bearden's Ford Gold Mine, Lumpkin Co., Georgia.—This is a rich gold deposit in the bed of the Chestatee River at an abrupt bend of the stream, where it is too deep to be worked even in the dryest seasons. A large amount of Gold was formerly taken out by boat shovels and by making "pens" or coffer dams or logs along the banks. During the past summer a canal for turning the river from its course has been in progress, under the direction of Dr. M. F. Stephenson. The canal is forty feet wide. Great returns to the precious metal are expected from the former river-bed during the winter.

Gold in the Valley of the Columbia.—We have letters from authentic sources in the camp of Capt. Archer of as late date as the 22d of July, from one of which we gather the following items: The *color* of gold was found almost everywhere on the march from Priest Rapids to the Similkamin; the prospects were best, however, in the vicinity of the Wee-nach-ee and Methow rivers. The water was quite high, and in the way of any thorough prospecting. A piece of gold, worth about ten dollars, was found by an Indian on the Similkamin some time ago. Just below Captain Archer's camp, and on the Okinakane river, is a very extensive copper mine of the pure metal. On the Chelan and Pend d'Oreille, lead is found, pure also; so that the country appears to be pretty well off in a mineral point of view, but thus far I have seen nothing to recommend it for agricultural purposes. There is, however, said to be a large fertile valley on the Similkamin, where stock can be wintered without hay or shelter.—*Dallas Journal.*

Later intelligence says:

Rich gold diggings have been discovered on a bar of the Similka-

min River, about 100 miles south-westward from Fort Colville, east of the Cascade Mountains. A party of U. S. soldiers were making $20 each in half a day—they could not work more than six hours per day, having to walk six miles from camp—with knives and pans; with rockers they could make $200 per day, and with sluices, $1,000. These reports come in private letters written by trustworthy army officers; and though published anonymously, they are known to be reliable. They state, however, that only one small bar has been found thus rich, and no other good diggings have been discovered in the vicinity; nor, indeed, has there been any thorough prospecting.

Oregon papers contain further accounts from the new Similkamin gold mines, representing them as a reality and probably extensive. Gold has been found a hundred miles above the point where it was first discovered. As evidence of the richness of these mines, an account says that the parties discharged from service immediately fitted out at Colville and went there, and soldiers who had not worked more than three or four months, exhibited $600 or $800 cash. Already several parties have started for the diggings. From the Dallas Company, about fifty organised at Portland for the same purpose, but there would be no great rush until Spring.

Large Ingots of Gold.—Two unusually heavy bars of gold have been received in New York from California. One weighed 2,227 ounces, .895 fine, and worth $41,219; the other weighed 2,251 ounces, .915 fine, valued at $42,581 71. They were assayed by Kellogg Humbert, of San Francisco, and purchased by B. Berend & Co., bullion dealers. The former was 12 inches long, 5½ deep, and 4 inches wide.

Mariposa Gold Mines.—Rights of Col. Fremont.—The California correspondent of the *N. Y. Times* says:—

The great event of the week is a decision of the Supreme Court of California, in the case of Biddle Boggs *vs.* The Merced Mining Company. This suit involved the question of Col. Fremont's right to the undisputed possession of his great Mariposa mines. The Merced Mining Company were squatters on the estate, and extracting the gold therefrom. Fremont leased the premises occupied by the said Company to Boggs, who brought suit to recover possession. The defendants, to resist a recovery, alleged, 1st, fraud in the survey of the grant, and the procurement of the patent by Fremont; 2d, estoppel from the declarations and conduct of Fremont; and 3d, a license from the Government to enter upon the premises and extract gold. The Merced Company have been in possession since 1851, extracting gold; and their works are stated to have cost over $1,000,000.

The court decide that there is no proof of fraud, and that, even were the fraud admitted, it would invalidate the patent, or, at least, that it could not be considered in an action at law. They leave the inference, however, that it might be inquired into by means of proceedings in Chancery.

The plea of estoppel is disregarded by the Court, who set forth the facts to show that it can be relied upon by the defendants. I omit the statements on this point because too long for a letter. The last point made by the defence was, substantially, that the minerals in the soil belong to the Government of the United States, or to the State of California, and have not become private property, the ownership of which passed to Col. Fremont with the *lands* on which they were found. Defendants claimed, therefore, that even admitting Fremont's title to the land, still they had the right to go in upon his property and take the gold out at will. The Court avoided passing definitely upon the question whether the precious metals in the soil pass with the latter, but declared that, whether the ownership of the minerals be reserved to the United States or be vested in the State, the Mining Company can have no right to enter upon the premises of the grantee, Col. Fremont, in order to extract and remove them. After showing that this claim to a right of entry for the purpose named would be in practice an intolerable trespass, the Court concludes its remarks upon this head by saying: There is something shocking to all our ideas of the rights of property in the proposition that one man may invade the possessions of another, dig up his fields and gardens, cut down his timber and occupy his land, under the pretence that he has reason to believe there is gold under the surface, or, if existing, that he wishes to extract and remove it.

The litigation of this case has cost Col. Fremont and his associates over $50,000. The result vindicates him from the long-pending charge of claiming a fraudulent grant, and effectually disposes of all the legal difficulties he has been compelled to contend against in the prosecution of his rights. It is safe to assert that his income from his mining estate will, within the next six months, be equal to $1,000 per day!

Assays of Pike's Peak Gold.—The following assays of gold dust from the new discoveries at Pike's Peak, have been made and published in this City:

Before melting.	*After melting.*	*Fine.*	*Amount.*	*Per oz.*
94.85 ounces	86.45 ounces	816	$1,459 15	$15 32
55.50 ounces	47.10 ounces	819	798 00	14 38
88.00 ounces	78.30 ounces	840	1,356 90	15 42

The falling off in weight on melting is owing principally to the sand in the fine dust, and to quartz in the coarse. In an ounce of dust there is from 14 @ 18 cents of silver, which something more than pays for assaying, if the parcels be 10 ounces and over. The

best sample of the above lot was fine bright dust, but quite sandy, while the poorest was partly coarse, and all of a dark, dirty appearance.

Fraser's River.—On the 23d November a steamer arrived at Victoria from New-Westminster, with about $100,000 in gold, and 175 passengers. The passengers gave a flattering account of the Upper Fraser's River diggings, but the prospect of a severe Winter was causing the entire abandonment of that region till next Spring. Lower Fraser's River was free of ice, and the miners were disposed to stay during the Winter. About 1,500 miners remain at the Vancouver diggings. The general impression at Fraser's River was, that there would be an immigration of 10,000 into British Columbia by the close of March, but there does not appear any good foundation for these extravagant expectations.

Major Downie was on his way down from the Upper Fraser River region by the Lillivet trail and Port Douglas. There were reports of his having made some valuable geographical discoveries on his journey from the coast to Fort Alexander, among which was a chain of lakes extending along the route one hundred and fifty miles, so that steamers drawing twelve inches of water can navigate a distance of 100 miles further than steamers drawing four feet, which latter run on Senas River, and a practicable portage of forty miles will then reach Fort Alexander. These reports are looked upon at Victoria as important—as, if true, the upper mining districts will be much more accessible than heretofore, being brought almost within water communication of Victoria.

SILVER.

Washoe Silver Mines.—A short article on this new silver mining district of our country, appears in this Number of the Magazine, giving such facts as have been received. By the last arrival from San Francisco, we learn that although snow had fallen to the depth of four feet in the Sierra, the immigration of miners to Carson Valley still continued. The news from the mines was encouraging, and new discoveries of gold, silver, and of lead, were reported. Over three tons of silver ore arrived at San Francisco on the 29th November. A share of one-fortieth in the original or Comstock vein, had been sold for $10,000.

Silver Mining in Arizona.—The correspondent of the St. Louis *Republican*, writing from Tubac, Nov. 24th, says:—

Our mining interests are daily becoming more important. The Sonora Exploring and Mining Company have an engine *en route* for the works, which will arrive early next year, and enable the Company to reduce their rich ore in quantities to render it very profitable to shareholders. They continue to get out weekly from five to eight hundred dollars, which is cast into small bars, and affords a convenient circulating medium. Their silver commands a premium of six per cent., and more in the States, and Sonora merchants prefer it to gold. The Cababi Company is also making arrangements to introduce machinery, and commence the work on an extensive scale, and the Union Mining Company, under the management of Col. Titus, is laboring vigorously for success.

There has recently been discovered in the Sacramento Range of mountains, some 40 miles east of this place, a new, or rather an old silver mine of surpassing richness. It was evidently worked more than a hundred years since, by the Spaniards, and, judging from the immense quantities of cinder found near the old furnace, it must have been worked very extensively. A company has been formed, and will proceed to make the necessary arrangements for the successful development of the mine as speedily as possible.

The machinery above referred to consists of two engines of twenty-five horse power each, with crushers and amalgamators. These were sent out overland *via* Port Lavaca, Texas, and El Paso, as the uncertainty of safe transportation from any of the Mexican ports on the Gulf of California was too great. This freight weighs 100,000 pounds, and is transported to the mines, 1,500, miles for fifteen cents per pound, costing the Company $15,000 for freight alone. The expenses from Guaymas to the mines would not have exceeded four cents per pound.

Stephenson Silver Mine, Fort Fillmore.—The Mining Engineer of this mine, Mr. Rittler, arrived there on the 1st December last, and had inspected the mines and smelting house. He reports finding five distinct veins cropping out for over 600 yards, and varying from four to twenty feet in thickness. These, he thinks, will be approached best by drifting in upon their course, and not by shafts. The road from the mine to the Rio Grande is a gradual descent and is in excellent order. Several assays of ore yielded from $104 to $156 worth of silver to the ton of 2000 lbs.

Reported Discovery of Silver near the Tejon, California.—A vein of ore supposed to yield silver, has been discovered near

Fort Tejon, but from the description given in the Los Angeles *Star*, which follows, it seems probable that the prospector has stumbled upon a vein of antimony glance, as this is the only ore we know of in that vicinity that will yield "30 lbs. of metal," in a common furnace.

About thirty pounds of the metal, obtained by smelting in a common furnace, was sent to San Francisco, on the Senator, yesterday; also, a quantity of the ore. It is the intention of the Company, nine in number, to prospect the lead thoroughly, by sinking shafts; seven men are now employed in this operation. The ore obtained was from the surface merely. About five feet down, the vein is fully two feet wide; and at the depth to which the men have now sunk, the vein is four feet wide.

Silver Mining in Norway.—The silver mines of the vicinity of Kongsberg, Norway, are now attracting the attention of the English mining public. It is reported that an English Company has purchased the Anna Sophia district, and intends to work it in a spirited manner. Operations have been suspended there since 1805. A correspondent of the London Mining Journal makes the following observations:—

"The Kongsberg Mines are unquestionably very remunerative, but the State retains in its own possession the very limited territory where native silver is likely to be found in sufficient quantity to pay for working. A Norwegian company has for some years been exploring the most likely district in the neighborhood of the Kongsberg Mine, and every year considerable calls have been made. The other setts were taken up by speculators without capital, on the chance of selling them in London; though such a transfer is, by the conditions of the auction at which the setts were acquired, illegal. No doubt silver exists beyond the bounds of the Kongsberg sett, for innumerable trials by private parties, as well as by the Government, prove it; but the quantity has been in every case utterly inadequate to meet the expenses; and whatever is found must be sold at a fixed rate to the royal smelting-house.

Silver Mines near Copiapo, Chile.—To the north of Copiapo, at a place called Tartal, new mines of silver and copper have recently been discovered, which, for richness, will compare favorably, it is said, with any mines in Chile.

The Honey Lake Silver Ore.—The *Red Bluff Beacon*, speaking of the various assays of ore from the Honey Lake silver mines, says:

Quartz taken from the upper vein, assayed at Marysville by Harris & Marchand, paid at the rate of $150 per ton; some from the same vein, assayed at Sacramento city by Blake & Co., paid $201 per ton, fair looking gold. The silver ore assayed at San

Francisco, by J. Mosheimer, (crushed, oxidized, and amalgamated), paid only $51 20 per ton, and some quartz from the lower vein $30 per ton, gold.

COAL.

Albert Coal of New Brunswick.—According to a letter from F. McDondald, Esq., agent of the Albert Mining Company, to the Editors of the *Scientific American*, the coal from this celebrated locality is not used at Hunter's Point, L. I., but only at the Kerosene Oil-works, South Boston, Mass.; Portland Kerosene Oil-works, Portland, Maine; and at the New Brunswick Oil Company's Works, St. John's, N. B. No other companies have had any of the Albert coal this year. The above three companies are under contract with the Albert Mining Company for the whole product of the mine until January, 1864.

The Coal Fields of Ohio.—It is almost melancholy to contemplate the vast beds of coal and ore in the United States, and see how little there has been done to develop them, while we are annually paying Great Britain millions upon millions of dollars for iron manufactures. The coal fields of the single State of Ohio are larger than those of Great Britain, while the latter has been used with such skill and energy as to create a manufacturing industry and production, beyond any thing the world has ever seen, in an equal space. What the British coal production now is, we find from a table in the *Merchant's Magazine*, as follows:

Collieries	2,095
Tons of Coal produced	65,394,707
In Bushels	1,634,867,707
Bushels produced in Ohio	50,000,000
Bushels produced in Western Pennsylvania	60,000,000

We find that Ohio can produce more than *thirty times the coal it now produces annually*, before it reaches the proportion of annual production in Great Britain. The entire amount of coal annually produced in Great Britain, may be mined in Ohio for 500 years, without exhausting more than *one seam*, while it is well ascertained that in a thousand feet in depth, there are four or five seams. The 12,000 square miles of coal in Ohio is scarcely a fourth part of the coal basin of which it is a part, comprehending large portions of Western Pennsylvania, Virginia, Kentucky, and Tennessee. This is the Eastern coal deposit of the North-Western States; but there is also a Western of still greater magnitude.—*Am. Railway Times.*

MISCELLANEOUS.

Reported Discovery of Tin Ore.—The discovery of a very rich deposit or vein of tin ore in California, was privately reported last summer, and we received a sample for examination, but no precise information of its locality was given. The last number of the Proceedings of the Boston Society of Natural History, contains a statement by Dr. C. T. Jackson, that tin ore has been found at Los Angelos, California, yielding 60½ per cent. of oxyde of tin. We doubt whether any tin ore occurs at that place, which is upon tertiary strata, though it is not improbable that the ore has been found in the mountains to the north.

Cinnabar near Yreka, California.—Among the recently reported mining discoveries, is that of a valuable cinnabar lead, about two miles from Yreka.

Missouri Lead.—The *Missouri Republican*, in a notice of the mineral wealth of the south-west part of the State, says:—"During the last four months, there has been brought to St. Louis, over the Pacific Railroad, 1,275 tons of lead in pigs, the product of the south-west counties of the State. This lead was worth here, on delivery, $130,089. By the end of next year, should the road be constructed as rapidly as we hope, the products of the south-west will be computed by millions, and the climate and other advantages, with the facilities of getting to market, will attract to it an immense population."

The Mineral Wealth of Great Britain for 1858.—We are happy, says the London *Mining Journal*, in being able to present an accurate return of the metalliferous and mineralogical wealth of the United Kingdom for 1858—the usual annual statistics compiled by Mr. Robert Hunt, F. G. S., being now completed. The return is remarkably favorable as compared with the preceding year; the value of the metals, metalliferous minerals, and coal, being thirty-one millions and a quarter in 1858, against twenty-five millions in 1857. Subjoined is the general summary of mineral productions:—

MINERALS.	*Tons.*	*Value.*
Tin,	10,618	£671,057
Copper,	226,852	1,336,535
Lead,	95,855	1,370,726
Zinc,	11,556	36,199
Pyrites,	100,263	77,123
Arsenic,	555	860
Nickel,	4	188
Uranium,	......	21
Manganese,	1,400	2,800
Gossan, &c.,	......	1,221
Iron ore,	8,040,959	2,570,701
Coal,	65,008,649	16,252,162
Total value of minerals,		£22,319,593

METALS.		
Tin, tons	6,920	£823,480
Copper,	14,456	1,562,693
Lead,	68,303	1,489,005
Silver, ounces	569,345	156,569
Zinc, tons	6,900	174,225
Iron,	3,456,064	10,713,798
Total value of metals obtained from British ores,		£14,919,770
Estimated market value of other minerals and metals,		£95,000
Coal,		16,212,162
Total value of metals, metalliferous minerals and coal produced in 1858,		£31,266,932

Mines of Nelson Co., Va.—The region of country in Nelson county, Va., near its junction with Albemarle county, is a mining locality of considerable value. The principal metal is lead, while copper, zinc, and silver, are also found in good quantities.

Plumbago in Maine.—It is reported that a specimen of pure plumbago, (graphite, or "black lead") weighing 250 lbs., has been taken from Puzzle Mountain, town of Newry, Oxford co., Me., where it is supposod an inexhaustible supply exists.

Cost of Coinage at the Mints of the United States.—According to a Table published in the *Alta California*, it appears that the average cost of coinage in the San Francisco Mint last year was $1 11 per $100, while it was $1 20 in the Philadelphia Mint, $1 70 in the New Orleans, $4 50 at the Charlotte Mint, South Carolina, and $8 at Dahlonega, Georgia. The average fineness of the deposits of bullion for the month of August, at San Francisco Mint was 8784.

AMERICAN MINING SHARE LIST.

This list we shall extend from time to time, until it includes, so far as practicable, every existing Mining Company whose stock is offered, or is likely to find sale in the market. As it is desirable that it should be correct, we solicit the co-operation of officers of Mining Companies.

Mining Company.	Office at	Location of Mining Operations.	Shares.	Paid in.	Present price.
Adventure, copper. . .	Pittsburg, Pa.,	Michigan,	10,000		
Arizona Land & Mining Co.	Providence,	Arigona,	....	....	$10 00
Aztec, copper, ...	" "	"	20,000		
American, coal, ...	New York,	Maryland,	60,000	$25 00	
Beaver Meadows Coal & R.R. Co.	" "	Penn.,	....	50 00	
Bohemian, copper, . . .	Philadelphia,	Michigan,	20,000	....	2 37
Buck Mountain, coal, . . .	"	Penn.,	....	50 00	
Central, copper, . . .	Pittsburg, Pa.,	Michigan,	20,000	1 35	12 00
Copper Falls, ...	Boston,	"	20,000	20 00	
Cumberland, coal, . . .	New York,	Maryland,	50,000	50 00	15 00
Dauphin Coal & R. R. Co., .	Philadelphia,	Penn.,	....	50 00	90 00
Delaware and Hudson, coal, .	New York,	"			
Eureka, copper, ...	" "	Tenn.,	10,000	50 00	
Evergreen Bluff Co., . . .		Michigan,	20,000		
Flint Steel River, . . .	New York,	"	20,000	4 00	3 00
Fulton, copper, . . .	" "	"	20,000		
Forest Improvement Co., . .	Philadelphia,	Penn.,			
Fond du Lac Mining Co., .	Superior, Wis.,	Wis.,	50,000		
Franklin, copper, . . .	Boston,	Michigan,	....	4 50	
Gogebic, copper, . . .		"	20,000		
Gold Hill Co., ...	New York,	N. C.,			
Hiwassee, copper, . . .	" "	Tenn.,			
Huron, copper, ...	Boston,	Michigan,	20,000	4 50	3 00
Hazelton Coal Co., . . .	Philadelphia,	Penn.,			
Irwin, coal, ...	New York,	"			
Isle Royal, copper, . . .	Washington, D. C.,	Michigan,	20,000	11 10	6 00
Lehigh Coal & Nav. Co., . .	Philadelphia,	Penn.,	....	50 00	
Locust Mountain, . . .	"	"			
Lykens Valley, coal, . . .	New York,	"	....	50 00	
Lykens Valley R. R. & Coal Co.,	" "	"	....	20 00	
Mass. Mining Co., copper, . .	Pittsburg,	Michigan,	20,000		
Minesota, copper, . . .	New York,	"	20,000	3 50	85 00
Merryweather, copper, . .		"	20,000		
Metropolitan, ...		"	20,000		
National, copper, . . .	Pittsburg,	"	10,000	11 00	85 00
New Jersey, zinc, . . .	New York,	N. Jersey,	....	12 50	
North American, copper, . .	Pittsburg,	Michigan,	10,000	30 00	10 00
New Jersey, Franklinite, .	New York,	N. Jersey,			
Norwich, copper, . . .	" "	"	20,000	11 00	1 00
North West, copper, . .	Philadelphia,	Michigan,	10,000	19 83	
North Western, copper, . .	Pittsburg,	"	9,000		
Nebraska, copper, . . .	Detroit,	"			
Pittsburg & Boston, copper, .	Pittsburg,	"	20,000	....	72 00
Phœnix Copper Co., . .	Boston,	"	10,000		
Pennsylvania, coal, . . .	New York,	Penn.,	50,000		
Pewabic, copper, . . .	Boston,	Michigan,	....	3 75	50 00
Portage Mining Co., copper, .	Detroit,	"	20,000		
Quincy Mining Co., copper, .	"	"	8,000	9 00	
Ridge Mining Co., copper, .	Pittsburg,	"			
Rockland, copper, . . .	New York,	"	20,000	2 00	30 00
Santa Rita, Silver Mining Co.	Cincinnati,	Arigona,	....	....	20 00
Sonora Exploring & Mining Co.	New York,	"	20,000	....	50 00
Sopori Mining Co., Silver,	Providence,	"	....	....	10 00
Southern Gold Co., . .	Boston,	Georgia,			
Springfield, copper, . . .	Baltimore,	Maryland,	100,000	5 00	
Superior, copper, . . .	New York,	Michigan,	20,000	2 00	52
Toltec, ...	Boston,	"	20,000	15 00	25 00
Westmoreland, coal, . .	Philadelphia,	Penn.,	40,000	12 50	

THE

MINING MAGAZINE

AND JOURNAL OF

GEOLOGY,

MINERALOGY, METALLURGY, CHEMISTRY, AND THE ARTS IN THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

FEBRUARY, 1860.

ART. I.—ON THE PREVENTION OF ACCIDENTS IN COAL MINES.

AT the meeting of the London Society of Arts, November 30th, 1859, an interesting paper with the above title was read by Mr. P. H. Holland, from which the following extracts, with an abstract of portions, are presented:

"Though I have had no immediate connection with the management of collieries, my attention has been very strongly called to this subject by having been instructed, in my capacity of Inspector of Burials, under the Home Office, to report upon the safest method of burying the numerous victims of the great explosion at Lundhill in 1857, by which 189 lives were lost. Two months elapsed before any of the bodies could be removed, and at the end of five months some still remained in the mine. Of course the removal and burial of so large a number of putrid corpses required the most careful precautions, but neither skill, care, nor expense was spared; and the free ventilation secured, the use of McDougall's disinfecting powder, Dr. Stenbruse's charcoal respirator, and other precautions, were effectual in preserving all the men employed in this

difficult, dangerous, and disgusting work, from any serious injury.

"It was of course impossible for me to have thus forced upon my attention a calamity so tremendous, by which 189 human beings were suddenly killed, 90 wives made widows, 220 children orphans, and a whole village deprived at once of so many on whom they were dependent for their daily bread, without strongly feeling the importance of adopting every practicable expedient for diminishing the recurrence of similar disasters, and inquiry soon convinced me, first, that the evil was of far greater magnitude than I was before aware of, and secondly, that precautions, the efficacy of which is well known and fully proved, and which are ordered to be observed by proper legal authority, are ,very generally, partially or wholly neglected, in defiance of humanity, of justice, and even of law.

"To prevent any possible misunderstanding, I am anxious clearly to explain that though this subject was first strongly brought under my notice in the execution of my ordinary duty, I have not the slightest official connection with the administration of the inspection of Coal Mines Act, nor are any of those who are connected with its administration at all responsible for, or even aware of what I am about to state.

"The magnitude of the evil is evident from the frequency with which the public are shocked by accounts of colliery accidents, particularly explosions, and the wide-spread and very, correct opinion that employment in coal mines is very hazardous, but I own I was not prepared to find that out of a number of about 220,000 colliers, 1,000 are annually killed, and of course a very much larger number severely though not fatally injured.

"During the last eight years there have been reported 8,015 deaths by colliery accidents, or 1,002 a year, showing a death-rate from violence exceeding four per thousand. I cannot calculate the exact proportion, because I do not know the increase of the number of colliers since the census, but the death-rate by accidents among colliers is at least from six to seven times as great as the death-rate from violence among the whole population, including suicides, homicides, and the dangerous occupations. If these were excluded it is probable that colliery work would be seen to be eight or ten times as dangerous as the average. In confirmation of this I may state that the charge of the insurance company against death by accident is for colliers eight times the ordinary rate.

"If this destruction of human life were inevitable, it would be melancholy enough, but I shall convince you that a very large part of it is not inevitable, that it would be very much diminished if the inspectors of coal mines could succeed in enforcing obedience to their regulations; and that obedience to those excellent regulations would be far better enforced if it were made the direct and palpable interest of owners and managers of coal mines to observe and to enforce them."

Mr. Holland here presents a statistical table showing the number of deaths occasioned by each great class of colliery accidents for eight years past. The total deaths for this period are shown to be 8,015, or an average of 1,002 a year; of which on an average each year 248 are from explosions, 371 from falls of roof; 217 from accidents in shafts, and 166 from miscellaneous accidents under and above ground.

With the exception of the year 1857, which included the extraordinary mortality at Lundhill, the number of deaths annually has scarcely increased since 1851, though the quantity of coal got, and the number of men employed, must have increased considerably. This result is attributed by Mr. Holland to such observance of precautions as the Inspectors have been able to induce.

"The next point to be noticed in the table is the proportion of different classes of accidents. It will be seen that deaths from explosions which alone excite much popular attention, form only one-quarter of the whole. These are all, or nearly all, preventible.

"In the northern districts, in which one-fourth of the coal is raised, and nearly one-fifth of the total colliers employed, the deaths from explosions scarcely exceed one-twelfth, the average being only 21 out of 248 annual deaths from this cause, and these may be still further diminished by constant attention to ventilation, and especially by the use of such safety lamps as the men cannot open without extinguishing the light.

"It is expressly enacted in the 4th section of the Colliery Inspection Act, that 'an adequate amount of ventilation shall be constantly produced in all collieries, to dilute and render harmless gases to such an extent as that the working places of the pits and levels of such collieries shall, under ordinary circumstances, be in a fit state for working.' And by the special rules, colliers are forbidden to enter the mines

until they have been examined by means of a lamp and found safe.

"If the simple and common rule were universally followed, of not allowing any unprotected light in any mine, unless and until the part of the mine worked was found safe, there could be no explosions except in those very rare instances in which an explosive admixture of gases and air is rapidly formed. Mr. Mackworth reported that 72 out of 73 explosions, and 171 out of 172 deaths were attributable to the use of naked lights, and that out of 1,154 deaths from explosions reported in five years, 12 only occurred where safety-lamps had been used, all of which were in a defective state.

"Mr. Kenyon Blackwell's evidence confirms this. He says that 'out of 1,099 deaths, 7 only were with safety-lamps, and adds that no instance has been properly authenticated of explosion from a proper safety-lamp; and in the most dangerous mines of England, where the discharge of firedamp is greatest, but where locked safety lamps are exclusively used, explosions are almost unknown.' (Colliery Report, 1857, p. 123.)

"In the northern district, where nearly one-fifth of the total colliers are employed, the average number killed per annum by explosion is only 21, out of a total of 248. If the average loss of life were reduced, as with equal care it might be, to the average of the north, instead of 1,984 killed during the last eight years, there would have been only 845. That is to say, that 143 lives are annually thrown away, because the precautions proved to be effectual in Durham are not observed in Yorkshire, Lancashire, Staffordshire, Wales, &c.

"Falls of coal and roof are the most frequent cause of injury. The deaths from these accidents alone have been 2,971 in 8 years, or 371 a year. Besides those killed by coal falling upon them, a very much larger number have been maimed and injured, often very seriously.

"It is probable that no reasonable degree of care will completely guard against these accidents, but it is certain that they may be very much diminished, as is proved by the fact that in the northern district, which employs one-fifth of the men, there are only about one-eighth of the fatal accidents of this class.

"This great difference appears to be chiefly owing to the plan adopted in the north, of employing men for the especial

duty of looking after the safety of the colliers. It is a special rule, nearly always ordered, but very generally neglected, that 'every collier shall securely sprag' (*i. e.* prop) 'coal while holing,' (cutting away beneath to make it fall,) 'and shall also, when necessary, prop the roof.' Any collier who neglects to do this is liable to fine or imprisonment; but it is neglected, and 126 men are annually sacrificed, and probably some thousands lamed in consequence. If a small part of the money lost by these accidents was expended in preventing them, the standard of danger might be reduced at least to that of the Durham mines, and 126 of the 370 annually killed saved.

"Often props are not sufficiently supplied; more frequently, in his anxiety to get as much coal, and thereby as much money as possible, the collier neglects the not immediately profitable duty of propping.

"In the northern district about one in six of the men employed are what may be termed the safety staff, for superintending ventilation, keeping up roads, setting timber, removing obstructions, and doing other things necessary for the safety of others. In most other parts of the country, colliers are expected to do most of these things themselves, and they are very much less properly done with the effect of an annual loss of 126 lives more than there would be if the danger were reduced to the Durham standard; and the northern mines are themselves susceptible of great improvement.

"The most dangerous part of the collier's employment seems to be in the shaft, for though most of them pass but a small portion of their time in or near the shafts, more than one-fifth of the deaths occur there. That many of these accidents may be guarded against, is proved by the fact that many of them occur which the most simple precautions would certainly have prevented. For instance, men could not be killed by falling stones or coals, if the cages were properly covered. Few are thrown out of the baskets or skips, when cages with proper guide rods are used. Few are drawn over the pullies when there are proper indicators, signals, and breaks, and when the engine driver's attention is not distracted by other duties. To neglect such means of safety is penal, but they are neglected, because their observance causes expense and trouble, and is not evidently and directly remunerative, though indirectly highly profitable.

"About one-sixth of the deaths, or 166 a year, are caused by miscellaneous accidents, the chief of which are crushing by coal tubs, or by passing trains. Many of these are the consequence of bad discipline, the want of proper control to enforce obedience to rule. Some happen because the galleries through which coal trains pass are too low and too narrow. Some by the employment of machinery and horses, where hand putting, though dearer, would be less dangerous, and many, no doubt, from the reckless foolhardiness of the sufferers themselves. The young seem to be the peculiar victims of this class of accident, partly because they are chiefly employed in the galleries, partly from their want of experience and caution. About twice as many of the boys below 15 are killed, as is the proportion to the number of them employed.

"Though the effect of the systematic inspection of collieries has induced the introduction of many precautionary arrangements, and, no doubt, has caused several hundred human lives to be saved, it has not produced all the improvement of which collieries are susceptible, and from the very nature of the case it never can. It was never intended that the Inspectors should be the substitutes for viewers, or mine engineers, who are so constantly employed by the owners of the northern mines, but not always elsewhere, to direct the general mining operations. If the Inspectors are to perform this duty, not only must their number be increased from 10 to at least a 100, but they must be invested with power enough to become in effect the real directors of the collieries in very important respects.

"The reports of the Inspectors give ample proof, both that precautionary regulations directed to be observed are very generally neglected, and that a very large proportion of the thousand annually killed are destroyed in direct consequence of such neglect.

"That such is the case in the great majority of instances is proved by the record of accidents, and confirmed by the fact that in the northern districts, where precautions are best observed, the proportion of fatal accidents to the men employed is very much less than that of the country. It is the general belief of those conversant with the subject, that the numbers really killed by disregard of the precautions ordered, is greater than has been proved, which is very probable, as it must often be impossible to get evidence of neglect, which many have an

interest in concealing, and under circumstances where the exact truth is apt to be obscured. Much good has been done, and much more no doubt will be done, by enforcing the penalties against those who disregard the regulations; but almost infinitely more might be accomplished if it were made the direct, palpable self-interest of all colliery owners, managers, and men, that whatever would diminish risk should be adopted. No doubt it is their interest, as the most intelligent of them are well convinced, but that is not always immediate and self-evident. The danger and loss are remote and contingent—the trouble, cost, and inconvenience of adopting precautions are certain and immediate. We are all more or less gamblers, and will incur a distant risk for a present gain, and most of us risk a distant loss which is out of proportion to the present gain.

"This is especially the case with those to whom the risk is habitual and the precaution new; they under-estimate the former and over-estimate the latter. For instance, it is abundantly proved, that the cost and inconvenience of using locked safety-lamps is very small in proportion to the risk of not using them, yet their introduction has been pertinaciously resisted. Once introduced, their use has rarely been abandoned. The reason, doubtless, is that the inconvenience and cost of them are constantly apparent, but the diminished risk is evident to the thoughtful only. If the reality of the benefit were fairly estimated, all opposition to their use would vanish. All that is necessary to effect this change is, first, to prevent those whose neglect and mismanagement occasion the accidents, from pushing off the loss upon others, and secondly, to arrange that the loss instead of being left to be paid at rare and uncertain intervals, when accidents happen, should be paid for in anticipation, that is in the form of periodical premium of insurance against the risk. Colliery accidents are sometimes but not generally very destructive to property, but the heaviest part of even the pecuniary loss results from the loss of life. For instance, the Lundhill explosion, which was unusually destructive to property, is supposed to have cost the proprietors nearly £20,000. The same explosion destroyed also 189 persons, and deprived those who were dependent on them for support of their means of livelihood. If the families so impoverished had had annuities purchased for them producing for ten years 10s. a week for each bread winner

killed, they would not have received full compensation for their mere money loss ; but to purchase such annuities would have cost, at £200 each, £37,800, or nearly twice as much as the estimated injury to the colliery itself. A part, indeed, of this heavy loss was borne by the owners of the colliery, who subscribed largely to the fund raised to relieve the sudden and utter ruin in which the families of their work people were involved, and to prevent their all becoming a burden upon the rates. The ratepayers also had a heavy share, though very unjustly, but its weight fell chiefly upon the families of the colliers suddenly reduced from comfort to want, and partly on those benevolent persons who contributed to relieve an amount of distress overwhelming to the immediate district.

"Upon whom ought such loss justly to fall ? Clearly not upon the families of those killed, who must inevitably suffer so deeply in addition to pecuniary loss, and who have done nothing to cause, and could do little to prevent, their misfortune. Clearly not upon the charitable, who have difficulty in meeting other claims on their benevolence. Nor upon the ratepayers of the parish which is so unfortunate as to be the scene of such disasters. It is clear that those alone who profit by a dangerous employment should pay for its risks, and that any loss which might have been avoided by care, should fall as exclusively as possible upon those who could and who ought to observe and enforce precautions.

"The cost of precautions, and of accidents which occur in spite of them, should be borne by the consumers of coal. The loss occasioned by accidents which might be avoided but are not, should be borne by those whose culpable negligence or cruel parsimony was the cause of them.

"This just and beneficial result might be attained by one of two plans—by a system of insurance against death by accident, or by such an extension of Lord Campbell's Act as would secure compensation to the families of those killed apparently in consequence of the neglect of any of the precautionary regulations legally ordered to be observed, unless it can be proved that the death was caused by the deceased himself, instead of its being necessary for the claimant of compensation to prove that the death was caused by the direct act or default of the master, whereas it is generally the neglect of some servant or fellow workman, who alone is pecuniarily responsible, but from whom substantial damages can rarely if

ever be obtained. The theory of the law in this respect seems to be, that the workman undertakes to bear all the risks attending the employment; and the danger and possible loss to himself and family is, it is presumed, paid for in the form of higher remuneration. Supposing this to be fair, so far as ordinary risks are concerned, surely it cannot be justly assumed that the collier is a consenting party to encountering risks arising from open violation of law, *e. g.* from the disregard of precautionary regulations the neglect of which is punishable by fine or imprisonment. I am told that damages are not now recoverable unless the injury can be proved to have been the direct result of the neglect of the defendant himself. What is needed is that it should be sufficient, in order to obtain compensation, to prove that the injury probably resulted from the neglect of a precaution ordered to be observed, but either habitually neglected or neglected at that particular occasion, either by the defendant himself or by some persons employed by him, unless it can be shown that the injury did not so result. In short, that proved neglect, the probable cause of the injury, should be *primâ facie* evidence that it was the real cause, and that coal-owners should compensate for injury suffered by those they employ, in consequence of breach of law either by themselves or their agents. The object would, however, be much more perfectly attained if no one were allowed to work in any colliery without being insured against death by accident, to a sufficient amount to secure his family from destitution, which would have the effect of compelling those to bear the loss who profit by the labor, and who can most control the result.

"It may be objected that either plan would impose a new and heavy tax upon collieries, and thereby injure a very important national interest. A little consideration will, however, show that it would be a great pecuniary advantage to the coal owners who do their duty—a large and increasing class—a heavy tax to those only who neglect it. Even supposing, contrary to all analogy, that high charges for insurance of colliers in dangerous mines, and low charges for those in safe ones, should have no powerful influence in rendering the dangerous mines safe, and the safe ones safer, the effect would simply be to transfer the burden of maintaining the families of those killed from those who ought not, to those who ought to bear it. By slightly enhancing the price of coal, the cost

of precautions against accidents, or of compensation for injuries sustained, might be paid for without injustice or hardship to any one. An increase of one penny per ton upon the cost of the 66,900,000 tons of coal annually raised, would amount to nearly £280,000 a year, or enough to purchase annuities worth £200 a piece for the families of the thousand men and boys annually, leaving a large margin for expenses of management and extra risks, and more than enough to pay for all reasonable means of safety, not in themselves profitable as they generally are.

"There is no doubt, however, that though the immediate effect might be only to relieve an enormous amount of severe and unmerited suffering, by increasing the cost of coal to a scarcely appreciable extent, a secondary effect, even more important and beneficial, would very rapidly follow.

"It must be abundantly evident that though coal-mine owners can add the average cost of insurance (if all must pay) to the price of coal, they cannot add that which is above the average, which will therefore be a loss to them, while any below the average is a gain to the individual owners who succeed in procuring for their mines a reputation for safety. They would therefore have a very strong motive for adopting any improvements in the working or management which would induce the insurers to lower the charge of insurance. Nor would this be the only, nor, perhaps the strongest inducement. The charge for insurance would be an indication of the risk, as estimated by those whose duty and interest it would be to estimate it correctly. Colliers would seek employment in the safest, and avoid the more dangerous mines, to which they would have to be tempted by higher wages, and the pits would be classified by the best, because the most experienced and unprejudiced judges. The extra charge for insurance, and the extra wages demanded for working in mines thus declared to be dangerous, would act like a heavy and constantly recurring penalty on those who persist in disregarding precautions; penalties far more certain of infliction and far heavier in amount than any a court of law would impose for neglect, however flagrant, short of manslaughter; penalties which must be charged, or the insurers would be ruined; penalties inflicted not on rare occasions, but constantly and inevitably, so long as the neglect of precaution continues.

"The plan might, moreover, be so arranged as to act as a

large and gratifying reward to those who succeeded in diminishing accidents, if, instead of lowering the charge for insurance, the insurers paid back a stipulated share of the profit to be spent for the benefit of the colliers in mines where losses were less than the average. On the occasion of such distribution of the profits resulting from successful carefulness, an excellent opportunity would be presented of proclaiming the success, explaining its causes, and enlisting the services of all the men to further improvement.

"Can it be doubted how this would operate? For instance, Lundhill Colliery exploded because it was not worked with safety-lamps, and 189 persons were killed. There is no intention of holding up the proprietors to special reprobation; probably they were advised that to use the safety-lamps was an unnecessary expense. After the explosion some so-called safety-lamps were found open. Would lamps which could not be opened, and which might have been supplied to every miner for less than £100, have been thought an unnecessary expense if the alternative had been either using them or paying, say £100 a year extra insurance against death by accident? Is it not morally certain that locked safety-lamps would alone have been used, that most of the 189 then killed would be now living, their wives would not have been widows, nor their children orphans, the mothers childless, nor households desolate; or, if contrary to all reasonable expectation, and notwithstanding all care, the explosion had happened, a whole village might indeed have had to mourn for their dead but would not have been pauperized. Mothers would have wept over their orphaned children, but the holiness of their grief would not have been mixed with fear of seeing those children pining from want, or of being compelled to consign them to the workhouse. Where the plan failed—and it would rarely fail—in preventing such catastrophes, it would at least alleviate the disaster."

In the discussion upon this paper which ensued,

Mr. ROBERT HUNT, F.R.S., said, that the subject which Mr. Holland had so ably brought before them involved a specific plan, by which he thought we might hope to preserve the working-miner from those accidents to which he was now subject, this means being a system of insurance. The Chairman had brought forward other circumstances involving risk, which he imagined to be analogous to those of collieries, viz., machinery in factories. He (Mr. Hunt) could not conceive

for a moment the slightest analogy between accidents resulting from the uncovered machinery of factories, and the many dangers to which the men working in collieries were exposed; the one they could guard against, but the other he believed, though he said it with much regret, they could not entirely guard against. At the same time, it was to the utmost degree important—it was important as an act of Christian duty—to use, to the utmost of their endeavor, the means of overcoming the difficulties with which they were beset in raising their fossil fuel. It was true, that a vast number of deaths were occasioned by the explosion of gas in collieries; many of these, however, arose, not from neglect on the part of the proprietors of the mines—not from carelessness on the part of the managers—but from recklessness and thorough foolhardiness on the part of the men themselves; and he knew, from having visited every mining district in the kingdom, that there was one belief which they could not drive out of the heads of those ignorant men—viz., that they would not die till their time came; and this engendered such a degree of carelessness that it seemed hopeless to attempt to deal with them. He felt quite sure, however, that the Collieries Inspection Act had done a great deal of good, for although there had been many terrific explosions, which kept up the number of deaths, yet if the general result were examined, it would be found to have been favorable, and every year since its introduction decided benefits could be traced to it. It had been said that a system of insurance would render the proprietors of collieries generally more careful as to the mode in which they carried on their operations. For his part he did not think so. He believed the proprietor's greatest interest was to preserve the lives of his men; for he knew that accidents happening in his mine were always attended with great cost to himself. They must remember that in general the proprietors themselves knew but little about the working of mines; they trusted those operations to their agents, who perhaps employed others under them; so that there were a number of people whose pockets were not immediately affected by accidents, but upon whom their occurrence mainly depended. He was quite certain that no system of legislation which should be compulsory, and that no system of inspection which should amount to something like the same thing, would be so effective amongst the proprietors as the persuasive system; and he was confident, from his knowledge of the proprietors, that

although they partook of the peculiar characteristics of the Anglo-Saxon race, and were strongly wedded to the customs in which they were born—yet still they were open to conviction, and they would not continue to go on in their old course, if it were pointed out in a satisfactory manner that they were wrong.

Mr. JOHN HEDLEY said he had listened with great pleasure to Mr. Holland's paper. There were many points in it in which, if the mining districts of England were alike in character, Mr. Holland might be right. For instance, in referring to the accidents in the mines in the north of England, it was mentioned that they were less frequent than in other districts. The roofs of the mines in the north were safer than in any other part of the kingdom. The danger from gas was not greater there than elsewhere. For instance, in the Barnsley district more gas was generated than in any part of the north of England. Mining operations had been carried on in the north for ages, and the mining population had grown with the extension of operations; they had become as it were part and parcel of the mechanism of mining. In the Midland Counties, in Lancashire and other districts, there had been a large introduction of strangers into the mines. English and Irish agricultural laborers had been introduced who were totally ignorant of mining operations; when directions were given to carry out certain details, they did not comprehend them, and did not carry them out. It was impossible that the proprietors could place an official at the back of each laborer to see that his orders were executed. General instructions were given, and they could only be generally carried out by giving directions to the various laborers employed in the mines, who were depended upon for carrying out those instructions. In the north of England they were carried out; in the Midland Counties and in Lancashire they were not carried out; the consequence was that accidents followed. Therefore, in making the comparison of the loss of life in each district, this must be taken into consideration. With regard to the improvements in mining operations, he felt bound to say that considerable progress had been made. He recollected several instances within his own district. In one very large mine the average loss of life was between six and seven in the year. He had carefully inspected that colliery, and was satisfied that such a state of things might be much improved.

He consulted with the owners and managers, and made suggestions which, he was happy to say, were efficiently carried out; and now, where the average loss of life had been six or seven in the year, there had only been a loss of one life during the last two years. Moreover, this was not an accidental circumstance, but was entirely the result of improvement in the discipline and general arrangements of the mine.

Mr. Robert Hunt said, in explanation, with regard to the non-analogy between uncovered machinery and coal mines, that he meant to say that in one case they had to deal with a single evil and in the other with fifty. In the one case, by covering the machinery they protected the individuals from injury, whereas in the other case they had fifty different causes of accident to deal with before they could hope effectually to protect the men. With regard to education, he concurred in what had fallen from Mr. Webster, and he most especially desired to see what had not yet been carried out—that was, that the lower orders should be educated—not simply in learning the signs of the ideas—but that they should be taught ideas which should have direct reference to the thing they were employed upon. They heard of hundreds of men being killed in collieries, and they lamented the accident; they talked of thousands killed every year, and they were alarmed; but they should not forget that far greater numbers were killed in the metalliferous mines than in the collieries; and it was an appalling fact that the average duration of metalliferous miners' lives throughout the kingdom was not above thirty-three years.

Mr. Holland would say a few words in reply upon the discussion. He had not stated that the means he had proposed would entirely prevent accidents in coal mines, but he had expressly said that some accidents could not be prevented by any precautionary measures. All he contended for was that it would tend to prevent some of these accidents and diminish their number. He was not so sanguine as to hope that the thousand lives lost annually would be saved. If they would save 500, or even 200, it would be a great thing. He had a confident expectation of saving 360 lives a year, or one a day, by the use of the means he had pointed out. He was obliged to Mr. Hunt for the remarks he had made, and he could not but think that upon a little more reflection, that gentleman would become an advocate of the views he (Mr.

Holland) had put forward—not for a compulsory system of insurance, but a compulsory payment from those who caused the accident, either by themselves or their agents, for the losses which their culpable negligence had occasioned. When a coal-owner, by himself or his servant, caused the death of one of his men, he should be compelled to compensate the family, as far as money could do so, as he would compensate a person not in his employ. The same protection which the law gave to third parties should be given to persons in the employ of coal owners. It would be very beneficial for collieries to be insured; but he did not assert that it would be desirable to make this compulsory. He had not much confidence that all coal owners would adopt the precautions which were proved to have been successful. There was a difficulty in getting them to use the proved successful precaution of safety-lamps. Mr. Hedley knew very well that the difficulty in getting safety-lamps fairly used was extreme; they had been pertinaciously rejected both by masters and men; and Mr. Hedley's evidence showed that the success of safety-lamps in preventing accidents was most signal. If they would not introduce safety-lamps, which scarcely ever failed, and where the supposed failures were only 7 in 1,000, was there any reasonable expectation that they would use other precautions? When the British Association met in Birmingham, a gentleman advertised that he would exhibit a contrivance to prevent the sudden running down of the cage with the men. That contrivance had been a good deal used; but he was informed, that although gentlemen of almost every profession went to look at the apparatus, and expressed their high approval of it, not a single coal-owner or manager of mines went to see it, because it was something new, and involved expense in its adoption. It took a long time to get improvements introduced, and he wished to quicken the progress. Accidents were most expensive to coal-owners. If the whole cost of the accidents were thrown upon the proprietor, a great inducement to prevent them was held out. Certain classes of accidents were very difficult to guard against, and they became dangers almost incidental to the business. But even these dangers could in some cases be diminished. The falls of roofs in the northern mines were far less numerous than the average in other districts, and less numerous in some mines than in others in the same condition. Why was this? For the reason he had

stated, viz., that in the mines in the north of England men were specially employed to prevent such occurrences. The Coroner for Preston had informed him that the reason why the falls of coal were so numerous there was that the men were employed to put up the props themselves, and they were so eager to get the coal that they neglected the propping. In the northern mines it was not so, but separate workmen were employed for that purpose. His firm conviction was that a system such as he had proposed would diminish the accidents very considerably. It would be profitable to the coal-owner and beneficial to the public, and he believed it would be advantageous to the country at large. But it was not upon that ground alone he rested his case; it was not merely because it was good economy, but because it was merciful and just; and He who had enjoined them to do justice and love mercy would bless their efforts.

Art. II.—ON THE FORMATION OF COAL.—By Prof. Leo Lesquereux.

[*From the Report of the Geological Survey of Kentucky.*]

In tracing the features, and studying the rocks and compounds of the earth's surface, no problem has more frequently occupied the mind of geologists than the formation of coal. Where does this black substance come from, hard as stone, and nevertheless inflammable as wood; half bitumen, half charcoal, encased between beds of shale and rock, which, by their fossil remains, their fishes, shells, or plants, attest the highest antiquity? Has coal been originated in the bowels of the earth by some volcanic agency, and deposited in a fluid state, like the lavas or the primitive rocks of many mountains? No! for it is stratified, laminated, extended in horizontal beds, covering very large surfaces with a nearly constant thickness. Moreover, the shales in which it is ordinarily encased bear evident proofs that they have been slowly deposited in a quiet water basin, and that subterranean fire has had no action upon them, except perhaps as a hardening agency.

Or, perhaps, has coal been made of the remains of extensive forests, overthrown, transported, and deposited again in valleys and hollows, by an universal flood. But, by such a cataclysm, those remains could not have been distributed in an harmonius manner, in extensive beds of equal thickness, and especially in such purity that they scarcely contain any particle of mud, sand, or any substance that does not belong to the chemical compounds of the wood. For the same reason, also, the beds of coal cannot be the result of heaps of drift-wood along the banks of the large rivers, or on the shores of the sea. It is then necessary to admit, with most of the best living geologists, that the coal beds have been formed nearly in the same manner as the peat-bogs of our own time, and that the coal itself is nothing else but decomposed and hardened woody matter, remains of immense and successive forests, grown, decayed, heaped up, and then entombed on the spot, in their gigantic shrouds of black slate, of black, white, and grey limestones, or of yellow sandstone.

But such an explanation is too general, too indefinite, to be easily understood, and especially to give a satisfactory account of the various accidents which have accompanied the formation of the coal. And since it is, from the nature of the shales of the coal-beds, and from the remains, whether plants or animals, found in connection with them, that the writer of this report intends taking the characters that may help to their identification, or to the ascertaining of their geological level, it is necessary to give, at least, the details that may be justly required, as reliable proofs of the validity of his opinion.

The vegetable is contemporary with the animal kingdom. Plants and animals have appeared at the same time on the earth, and grown together in parallel lines—for the remains of marine plants or fucoides are found in the oldest stratified rocks, in connection with the petrified remains of shells. As soon as a part of the earth's surface has been thrown out of the sea, like a new-born child, nature, its kind mother, has covered it with the green carpet of another vegetation. But the rise of a solid surface above the sea does not appear to have been a sudden and paroxysmal event. Impelled by the action of an internal fire, the crust of the earth, still thin and scarcely solid, was continually swelling here and there, with a variety of undulating movements—ascending and then subsiding at the same place—either propelled by the internal

fire, or depressed by its own weight, when the force lost its energy. In this manner, ranges of hills began to appear, breaking the monotonous horizon of an universal ocean ; and at their base, immense plains, levelled by the long protracted action of the waves, being by and by raised to the surface and separated from the sea by heavy banks of sand, were thus transformed into shallow marshes, prepared for another kind of vegetation. Such marshes, though of a far more limited extent, are seen in our time along the shores, both of the Atlantic and of our great lakes, the Dismal and Alligator swamps of the south ; the Sandusky, Montezuma, and Toledo marshes of the north.

But before those immense plains were thus slowly elevated and separated from the vast deep, the sea came for a long time, breaking its waves against the primitive hills, or at least, was long engaged in depositing around their base the mud with which its waters were charged. Those gigantic deposits of red sandstone, bordering the coal basin on its eastern margins, are especially the work of the tides. Like the conglomerates which were afterwards deposited upon them, they thicken to the east, and nearly disappear in the contrary direction, evidently showing where then were the first shores of the ocean—the first outline of the Alleghany mountains perhaps.

The conglomerates of the anthracite basins of Pennsylvania are about fifteen hundred feet high, composed of sand and pebbles of quartz, which are sometimes as large as hens' eggs. On the contrary, in the western part of the Coal Measures, in Indiana, Kentucky, and Tennessee, they are comparatively thin, and of a finer texture—just as it happens that near the shallow shores of our lakes, or of the Atlantic, the gravel and coarse materials of the bottom are heaped by the waves nearer to the margin, in proportion to their size, the finest particles of sand being necessarily drawn farther from the shores where the action of the waves is less violent. It was in this manner that the first basin of the coal was prepared. Bordered to the east by a chain of hills, the bottom was slowly upheaved, and the ocean dammed far away to the west, began there, by its perpetual movements, to build again its new shores, and to close in the coal basin with high banks of sand and gravel. This separation was necessary, for a shallow, quiet water, of a constant level, is the first condition of the formation of peat, and consequently of coal.

The plants of the bogs have a peculiar growth and a peculiar composition. They live ordinarily half immersed in water, and raise their stems, branches, leaves, and flowers above the surface. They are generally of a woody texture. Even the mosses and the grasses of a peat-bog contain, comparatively to their size, as much woody fibre as the hardest oak. The trees are most of them resinous. In the northern part of the United States the balsam-fir, the black and white spruce, the tamarack, the arbor-vitæ and the white cedar; in the south, the bald cypress, the great and small laurel magnolias, the tulip-tree, are commonly seen growing on the cedar swamps, with birches, alders, poplars, and other resinous shrubs. The peat bogs of Europe are abundantly covered with a kind of dwarf-pine, from the leaves and twigs of which the rosin trickles upon the mossy ground, forming all around the trees a hard floor of tar many inches in thickness. Most of the plants of those marshes, except a few trees, belong to that peculiar station; they do not grow out of their bogs, neither can they be transported and cultivated out of them. For that reason the vegetation of the cedar swamps cannot be taken as a true representative of the flora of a whole country. It has its place in the harmony of nature, like the fruits and flowers of our gardens, the grass of the prairie, the trees of the forest. It was destined for the condensation, the preservation of carbon, for the formation of coal. For truly, when we examine fossil plants that have been preserved in the shales of the coal, or when we analyze the substance of the coal itself, we find that the plants which formed it have the greatest likeness to those of our actual peat-bogs, viz., the ferns, the club-mosses, the horse-tails, the rushes, the reeds, and especially the resinous trees. The most remarkable difference is that all these plants, compared with those of our time, were of a monstrous size. They were indeed, the mastodons, the mammoths, of the vegetable world.

Everybody is now acquainted with Liebig's explanation of the combustion and decomposition of wood. When heat is applied to it, it burns with flame, developing carburetted hydrogen. When woody fibre is brought into contact with air, in a moist condition, it is gradually decayed, viz., changed into mould or humus, by the conversion of the oxygen of the air into the same volume of carbonic acid. Its carbon is then not only preserved, but augmented. When the access of

air is restrained, decay, or a slow burning of the wood, is in like manner produced, but the process is different. The disengagement of carbonic acid, though continuous, is slight, and the final result is charcoal, wood-coal, lignite, mineral-coal, anthracite, even diamond, according to the conditions under which this slow burning has taken place—the quantity of water, the more or less free access of the oxygen of the air, compression, heat, &c. Says Liebig: "A slow but continual removal of oxygen in the form of carbonic acid, from layers of wood-coal, or of wood immersed and decomposing in water, transforms necessarily the woody substance into mineral coal. On the contrary, the removal of all the hydrogen of mineral coal, converts it into anthracite." From this we draw the conclusion, that for the formation of coal, a large production of woody fibre, at a constant water level, is a necessary condition.

The presence of the water, and its constant level, are necessary not only to prevent a too rapid decomposition of the wood, but also for the vegetation, itself, of the marshes. Plants living entirely immersed in water, do not have a larger proportion of woody fibre in their tissues. The fucoides, or marine weeds, are of this kind. To elaborate wood, the plant wants the contact of the air with the porous surfaces of its leaves. The marsh plants, then, having their roots fixed in the ground below water, expand their leaves either on the surface of the water or above it. Trees need, for their vegetation, the absorption of air through their roots. Hence, those which grow on the bogs, extend their roots and rootlets in a large circuit, let them run near the surface among the mosses, and ordinarily plant themselves on a higher level, either on the decayed trunks of other trees, or some heap of matter. In any case, a formation of peat is impossible in a marine basin not entirely secured against the action of the tides, or in the marshes of rivers, which, though covered with high water in the spring, become dried by the heat of the summer months. Along the shores of the ocean, of our lakes or our large rivers, there are extensive marshes, inaccessible during the spring, and even during part of the summer, covered with rushes and reeds, the bottom of which is constantly and slowly elevated by thin layers of mud or clay, but never covered with peat.

The same phenomenon is produced in lakes and bayous, where water is too high for the growth of the plants, and on the borders of which the water level is not constant. The

matter deposited at the bottom of those deep marshes is constantly a fine mud.

There is perhaps no place in the world where the process of the formation of coal may be studied, with better chances of a clear elucidation of all its phenomena, than in the Dismal and Alligator Swamps of southern Virginia and North Carolina. The extent, though truly nothing compared with the area of the coal-fields of America, covers, nevertheless, thousands of square miles. They are separated from the bays and sounds that surround them by broad hills, and large banks of sand, bordering the Atlantic, in a continuous row, from cape Henry, or Norfolk in Virginia, to the mouth of Cape Fear river, or Wilmington in North Carolina. They contain, in their wide area, sand hills, deep deposits of peat, and lakes. The hills are covered with the vegetation of dry land. The peat, from one to fifteen feet thick, follows at its bottom the irregularities of the surface on which it rests, thinning and disappearing entirely where it abuts against the hills: for a bed of peat, depending for its formation on the level of the water, has just the same appearance, or at least, by a cross-section, would present the same front as the transverse soundings of a shallow sheet of water.

As for the vegetation itself, and its action on the formation of the peat, let any tourist try to find his way directly across the swamp, from some point on the canal to Drummond's lake and he will understand at once all about the mystery of the heaping of vegetable matter. Wading at least knee deep in water, or in a black soft mud, or sinking at every step deeper and deeper in the hillocks of green mosses, where he thought to find a dry and solid footing for a minute's rest, he has literally to cut a path through a wall of canes, of reeds, and of shrubs. The only place where he finds firm stepping and a clear space, is on the roots of the bald cypress, which raise themselves above the water around each tree, like the scalped skulls of a tribe of Indians; or, perhaps, on the prostrated trunk of a huge magnolia tree, covered with mosses, and slowly sinking in its muddy grave, not to decay, but to be embalmed and preserved like an Egyptian mummy. Every year the mingled mass of vegetation, the mosses, the canes, the reeds, the trunks, branches and leaves of the trees and shrubs, are heaped and deposited on the surface of the bog, to be, by and by, transformed into combustible matter, by the process of slow decomposition.

Some of the lakes now open on the surface of the marshes have certainly been hidden, formerly, by a thick coat of vegetation. Drummond's lake is only fifteen feet deep, and its bottom is strewn with the remains of an overthrown forest, which has probably sunk by its own weight. Phenomena like this are frequent in the large peat-bogs of northern Europe, especially in Sweden, Denmark—even in the mountains of Switzerland. The green carpet of vegetation which, by the agency of floating mosses, spreads on such lakes, is sometimes so thin that it breaks under a light pressure, and men and animals are frequently engulfed and irretrievably lost in their treacherous waters. The rich cabinets of Lund and Copenhagen are filled with antiquities collected in the peat-bogs of that country—weapons and armor; ornaments of copper, silver and gold; tools and instruments of every description; bones and skulls of extinct or living races of animals; of men also; even the whole skeleton of a woman, with her clothes, have been found imbedded in the peat.

Drummond's lake has now been open for many hundred years; its black water has entombed its sunken forests under a bed of mud. The surface of the lake, like the general surface of the Dismal Swamp, is only 16½ feet above mid-tide of the Atlantic. If we suppose a slow depression of all the space covered by the Alligator and Dismal Swamps, of say only a few feet in a hundred years, what would be the result? At first the water rises above its former level, since its outlets are necessarily obstructed, and the remains of the plants still growing here and there upon the hillocks of the marsh, fall every year into the water and sink to the bottom—not to add any more matter to the bed of the peat, but to be incorporated with the soft mud continually deposited by the water. If the downward movement continues, every trace of vegetation must disappear, and the marsh forms an extensive lake, connected by some outlet with the sea, which brings to it a few species of its inhabitants, either fishes or molluscs; and, by and by, after a still lower depression, either the sea spreads quietly over the whole space, and its water covers it with a deposit of limestone, wherein are imbedded the remains of the shells and animals of the deep; or, perhaps, after a sudden cataclysm, there is a depression of a few feet, and the sea, overcoming its barriers, rushes into its old level, sweeps over its old bed with impetuosity, and brings with its waves the banks of sand and

the gravel of its shores, to scatter them more or less irregularly over the whole surface. Let the land rise and the water recede again, and the formation may be repeated many times, with many modifications. This simple work of nature, operating in this wise for an immense number of centuries, will necessarily result in the transformation of the whole stratum to true Coal Measures. The compressed and crystallized peat will be the coal; the soft mud slowly deposited upon it by quiet and shallow waters, will be hardened to black shales, and show us the petrified remains of plants, shells, or fishes. The deposits of the deep, quiet, marine waters, have formed a bed of limestone above it, and if, afterwards, sand has been brought in by the currents of the sea, the whole measures—coal, shales, and limestone—become covered with sandstone.

The only thing not explained above, is the formation of the fire-clay of the bottom, which, by a cross-section, would certainly be found under the coal of the Dismal Swamp, as it is found under nearly every bed of the old Coal Measures.

As we have seen before, the woody matter deposited in a basin can only be preserved and transformed, if the water is of a constant level. Resting on the sand, the water percolates through it, and consequently is subject, by a constant motion, to a perpetual change of chemical constituents, and to a renewal of the particles of air which it contains. This change is opposed to the formation of peat, since water, before being prepared for the preservation and transformation of woody substance, has to become saturated with a peculiar acid—*the ulmic acid*—produced by the decomposition of wood itself. Thence it follows, that a peat or coal basin has to be separated and prepared to keep its water, like a well cemented cistern. This work is done by very small animals—*infusoria*—and by peculiar species of plants. In the peat formations of the present day the clay bottom of the bogs is prepared by fresh water molluscs and infusoria, and by the vegetation of the *aceæ* and *confervæ*, two families of cryptogamous plants, which disappear entirely, as soon as the peaty vegetation begins. They fix in their shells, or in their tissue, the carbonate of lime or the silica, abundantly dissolved in some water, and by their decomposition they deposit those substances at the bottom of the water in the form of a very fine mud. In Denmark, there are some perfectly isolated ponds, where this soft mud or clay is formed, by the agency of the above-named ani-

mals and plants, at the rate of one foot and more in every five years.

As there is no bed of peat, but is underlaid by soft white clay, so there is no bed of mineral coal without its bottom of fire-clay, except when it has been deprived of it by some accidental circumstance. This fire-clay is free from remains of animals and shells, but it contains very abundantly the stems and leaves of a species of plant, *Stigmaria ficoides* (plate 7, fig. 2,) which undoubtedly, like the *Chara* and the *Horsetail* of our time, has especially contributed to fix the silica, and to precipitate it to the bottom with its remains.

In this abridged exposition we cannot discuss the value of any of the above made assertions. Nevertheless, not one of them has been admitted without a critical examination, and after its truth has been ascertained by serious researches, or by reliable authorities.

The formation of the coal being thus understood in its whole, it is easy to draw from it the explanation of the different modifications of the Coal Measures, and to deduce some general rules for the identification of the veins.

I. THE FIRE-CLAY.

This clay, ordinarily full of rootlets and stems of stigmaria, so generally underlays every bed of coal, and its general appearance and chemical elements are so much the same, that except, perhaps, for its general thickness, it cannot become a very reliable guide for the identification of the beds. Even its thickness is variable. It depends on the depth of the basin in which it is formed, and on the regularity of its bottom—thickening in the hollows, and sometimes entirely disappearing near the margins of the basin. Variously tinctured by more or less of oxide of iron, it is generally whitish, but sometimes, as red as ochre, and even variegated like marble, in the same bed. The quantity of *Stigmaria* found in it is as variable as its color, and as for its chemical elements they depend, like the color, on the mixture of iron and lime, especially silica and alumina, which are never uniformly distributed in a wide expanse of shallow water. This fire-clay of the Coal Measures appears sometimes alone, and without any bed of coal above it. In which case it may be intermixed with layers of shales, covered with the remains of plants, especially of

ferns. Then it indicates only the place which was prepared for the vegetation of a bed of coal. Some accident—the shallowness of the water perhaps, or some disturbance of its level—has prevented the growth and accumulation of vegetable matter in sufficient abundance to form the coal. But the plants, growing upon the marsh, have been imbedded and preserved in the shales above the fire-clay as testimony to its natural destination. Nevertheless, those isolated beds of fire-clay, overlaid by plants, are not always barren of coal, and by following them to some distance the coal is often found somewhere reposing on their surface. The fire-clay is generally a reliable guide for the identification of veins, when it separates two beds of coal, forming what is generally called a clay parting. In this case, it is ordinarily found, though of variable thickness, over a wide extent. But it is then formed like the shales ; in some cases, it is even a true shale, and it is in the examination of the shales that the reason of its formation, and of its appearance, ought to be looked for.

II. THE COAL.

There is no substance of which so many chemical analyses have been made, and none, also, of which the chemical elements are so well known. The general result of all these analyses has proved a curious fact, viz., that two pieces of coal, taken from the same bed, at only a few feet distance, have scarcely ever presented exactly the same proportions in the quantity of their essential compounds. The reason of this is easily understood : each plant, especially each kind of tree, has for its wood a peculiar composition ; each one is more or less resinous, hard or porous, has more or less of woody matter in an equal volume, and each plant has a peculiar acid ; all the essential elements are locally preserved in the coal. The same remark is true of beds of peat, of which two slices cut either horizontally or vertically, at a distance of one or two feet from each other, never present exactly the same appearance, nor exhibit exactly the same proportion in their chemical elements. Some plants of the coal—the *Calamites* and the *Stigmaria* especially, fix in their tissue the silica of the water, and the quantity of ash varies in proportion to their abundance in the coal. Some others are porous, and when lying on the surface of a bed of coal, they let particles of mud

percolate through or within their tissue, and produce the same result in another way, and at another place. From these different causes, the ashes of the coal have a different color, and the distinction of white ash and red ash coal, which may be of great moment in the identification of the beds of part of a basin, is, when considered in a general point of view, of little value. If we may rely on the sections of the anthracite basins of Pennsylvania as they are generally given, the upper beds of it belong to the red, the intermediate ones to the grey, and the lower ones to the white ash series. In the coal-fields of western Kentucky and of Illinois, the upper beds of coal are white ash, the middle ones red, and the lower grey or reddish.* The classification of the colors could not be more completely reversed.

This color of the ashes is probably, also, in immediate connection with the nature of the vegetation which has formed the coal. In the peat formations the matter formed by the heaping and decomposition of trees gives white ash; a compound of small herbaceous plants, ferns, rushes, canes, mosses, gives red ash; and a mixture of both forms the grey color of the ashes of some beds.

The external appearance of the coal is as much varied as its chemical elements. The trees, sometimes, when they are very resinous, have formed, by their decomposition, such a compact and homogeneous mass, that the coal receives a peculiar appearance; it is then known by the name of *cannel coal.* Another species of wood preserves, even in the coal, some trace of its primitive texture, and shows, in its fracture, a peculiar reflection of light, called, by the miners, the *bird's eye.*

The coal is mostly stratified in thin laminæ or coats, alternately shining and dull—an appearance which clearly indicates an annual deposit of decayed vegetable matter, and the action of the water on it, during the winter time, or before the beginning of a new vegetation. The stratification of peat is exactly the same as that of coal; but the layers are variable in thickness, from the sixth of an inch to one inch and more, becoming naturally thinner under a great compression, and nearer to the bottom of the beds.

* Table of analyses of coal from saline and other localities, in the Geological report of saline coal mines and Manufacturing Co. p. 60, *by D. D. Owen, Cincinnati*, 1855.

The laminated appearance of coal is already a proof against the often repeated opinion, that it has been formed by the overthrow of vast forests; but there is a more conclusive argument against it. One acre of ground, covered with dense forest, and when its yield is carefully estimated, would afford, in 120 years, 10,450 cubic feet of wood; supposing the growth of peat to be only one foot in the same number of years, one acre of bog would produce 19,660 cubic feet of peat, (measured dry, and ready for burning.) A thick forest, overthrown by a cataclysm, and buried in the sand would scarcely make three inches of coal. But some peat-bogs of Ireland, Germany and Switzerland, which have continuous beds of peat twelve to fifteen feet thick, would, if they were transformed into coal, produce three to five feet of hard mineral coal.

For a better understanding of the different features and various appearances of coal, it is necessary to remember that the woody substance in its decomposition or slow burning, and before arriving at its hardened state of mineral coal, is ordinarily subjected to a softening process. The low part of a bed of peat is, in most cases, a black paste. In the old lignite deposits of Germany, large trunks of trees, perfectly blackened, are heaped and flattened into beds of six feet to nine feet thick, and their woody substance has beeome so soft that the workmen can easily cut it with their shovels; hence the flattening of all the stems in the coal and the shales; the remarkable appearance of immense pieces of bark rolled and pressed together, like sheets of paper; hence, again, the compactness of some coal; the evident stratification or lamination of others; the remarkable action of the sulphuret of iron, in transforming into pyrites whole flattened stems, or in preserving in the cannel coal of Breckinridge the outlines of the stigmaria, and of their leaves, with such neatness that they look as if they had been painted in yellow, on a ground of black.

The thickness of a coal bed, notwithstanding contrary assertions, is scarcely a reliable guide for identification; though as it has been previously explained, the coal is formed on a continuous surface, and not deposited here and there in hollows of various extent, depth, and directions—for this thickness depends on the evenness of the bottom upon which it rests. When a bottom of sand, or of any other loose substance whatever, has been for a long time covered by a deep

sea, it is mostly even and unbroken; a bed of coal formed upon it is generally of continuous and of equal thickness. But when two beds of coal are only separated by a thin formation of sandstone, and consequently have been formed at a short interval from each other, the sandstone covering the lower bed often bears, on its surface, numerous wrinkles and furrows, as an evidence of the action of turbulent waters. In this case, the coal formed above it is only piecemeal, in separate layers, thick in places, then rapidly thinning until it disappears, to be again found at a distance of a medium thickness, and continue for a while.

III. THE SHALES OR ROOF SLATES.

The shales are mostly a compound of the finest particles of matter, deposited in such a way that they are generally laminated in thin sheets, probably a result of periodical influences. If the movement of depression, marked by the formation of the shales, has been as slow as all the appearances lead us to believe it, the water raised above the marshes, was at first nearly of the same depth, and covered the whole field. If we suppose that some essential elements of this water had the power of consolidating themselves, and of imbedding and preserving all the low plants and the leaves falling on the marshes from the trees; if we suppose further, that by breaking the hardened mould, we could still now find the remains of those plants perfectly well preserved in the stones, we cannot but admit that those prints of plants would give us a pretty exact idea of the vegetation of the marshes of the coal epoch. It is just what has happened. Whenever, during the formation of the shales, the movement of depression has been so slow that for a length of time the marine water has not invaded the marshes, the deposited shales contain remains of plants only; but when the depression has been somewhat more rapid, the deeper water has arrested the vegetation, and the scantily preserved remains of plants are old, much broken, mostly stems, fruits, and pieces of bark of a hard texture, mixed with some shells.

The presence of the shells in the shales, proves the access of the marine water; it is ordinarily accompanied with some fucoid plants and fishes. The fucoid plants are generally scarce in the coal slates, and the shells, though often represented by an immense number of individuals, are limited to a few species, which differ from those of the limestone, and

seem to be of the kind generally living in the contact of the tides with the fresh water of the lakes or rivers. The slow propagation of those species lead us to suppose that they were distributed on a vast area, upon the beds where their remains are found. Therefore, if we can admit, that after the formation of each bed of coal, either the plants, or the animals that lived in the water which covered them, were of peculiar species, or at least that some species of plants or shells have either appeared for the first time in each bed of shale, or that identical species have been distributed in each of them in a different proportion, it is evident that the examination of the top or roof shales of the coal, and the study of their remains, whether plants or shells, must give the most reliable character for the identification of the beds of coal.

There is no doubt, but after the formation of each bed of coal all the plants and animals belonging to it have been destroyed, or at least removed far away. The vegetation of the marshes has been covered by thick beds of shales; the shales themselves, with their own inhabitants, have been again covered either by marine deposits of limestone, showing the remains of other peculiar species of organized beings, or by sandstone swept in by the high sea, and entirely destitute of animal remains. But even, when a bed of coal has again been formed over the marine shales, without any intermediate stratum, the formation of the fire-clay and the vegetation of the coal, both entirely barren of marine animals, both indicate a condition of things and a lapse of time which would, in all probability, have destroyed even their germs. If then, after the formation of a new bed of coal, and after an immense number of years, the downward movement of the surface brings again over it, the marine water and its inhabitants, is it rational to expect that this water will be still charged with the same species of animals as before, and that those animals will be distributed in the same proportion? Is it even rational to suppose, that all the circumstances producing the overflowing will be the same, with the same proportion in the quantity of marine water, the same chemical elements, the same depth, the same temperature, &c., &c. If there is only a small change of the elements dissolved in the water, (and truly, all the shales at different levels present different appearances,) it is certain that this change ought to have influenced the life, viz., the distribution of animals in the shales.

It is even so with the plants. The surface of a marsh

having been overflowed, and its vegetation destroyed, we cannot but admit that if it begins again in a new sheet of water, and after a number of centuries, the distribution of this new vegetation will be somewhat different from the former. If there are no new species of plants, and certainly there ought to be some, at least some of the former plants have entirely disappeared and those which have been left are grouped in another proportion. Nature bears in one hand its scythe of death, and in the other its cup of life. At every geological change that closes the career of some living species, there appear some others, that were prepared for existence and begin their mission. And although human life is limited to a day, in comparison with the innumerable ages of our world, we can sometimes observe those changes, and even analyze their causes. In the peat bogs of some high valleys of Switzerland the bottom of the marshes is strewn with large trunks of oaks, and there the climate is so cold now, that the pines alone can grow. In Denmark this change of vegetation is also remarkably observed in deep bogs, which the proprietors find profitable to dry with hydraulic machines for the timber which they exhume. One of the most remarkable of them has been explored and described, more than ten years ago, by the writer of this report* as its bottom, over the fire-clay, was first found four or five feet of very black peat, overlaid by a forest of pines, lying in the direction of the dip of the basin, viz., their roots against the sides. The diameter of many of their trunks was about one foot. Over the pines a bed of black peat, five to six feet thick, was still covered by an overthrown forest of white birch trees. A new bed of peat, six to eight feet thick, had buried it under its formation, and was overlaid by a third forest of oaks, of which the trunks, three to four feet in diameter, were so well preserved that they were sawed on the place and used for timber. Over this lay five to six feet more of peat, and the whole deposit was covered with humus, and a living forest of beach trees. The whole formation measured about thirty feet.

Along the shores of the Ohio and Mississippi river there has been deposited here and there, in different places, a quaternary formation remarkable for its thickness. Near Columbus, Kentucky, it elevates its white banks 160 feet above the level of the Mississippi river.† In its upper bed—a fine sili-

* Exploration in the north of Europe, for the study of the coal formations (Neuchatel, 1846.)

† First report on the Geological Survey of Kentucky.

cious loam—there is an abundance of shells, which, except one species, are still found living in the river below. This single species, either entirely disappeared or transported to some distant region, is sufficient to prove that if a new bed of loam was deposited now above the one mentioned, a close observer would already find a difference in their fossils. The lower bed of this quaternary deposit contains a quantity of leaves, already carbonized, the outlines of which are perfectly well preserved in the hardened white clay. Among them, the predominant species is an oak, (*puercus virens,*) which, in our times, has its peculiar station along the shores of the ocean, and scarcely grows out of the reach of marine water. There is in those remains of fossil plants very few of the species now living along the Mississippi and the Ohio rivers. A new deposit of leaves, now, would show a great difference between the vegetation of this last with the former one. Such difference in the recent formations may be observed in many places. From this it seems rational to admit, that two beds of coal, separated by various and sometimes thick strata of another nature, ought to present certain differences, in the remains preserved in their shale—some peculiar character which may enable a palæontologist to identify each of them, or to know their geological level at every place where it is possible to see them open for a careful examination.

Though the exposition of those principles is new, the best living geologists—Lyell, Brongnart, Burat, &c., &c.—have acknowledged their truth. For they have admitted that the palæontology of the shales would in time direct the identification of each bed of coal. M. de Humboldt, himself, says in his Cosmos: "That where several series of coal strata lie over one another, the genera and species of plants are not generally mixed, but arranged in a peculiar order for each bed."

The roof shales are subjected to some variation like the other formation, but they are rarely liable to modifications that can prevent their identification. Their thickness varies according to the depth of the water in which they are found. This depth of water, as we have before stated, would be nearly the same through the whole extent of a coal basin, if there had not happened some local depressions, caused either by volcanic commotions or by peculiar sinkings of the floating mass of vegetation. Those local depressions have caused the separation of a bed of coal into two or more branches, and sometimes its entire disappearance among high banks of black

shales. Such cases are not very rare. Then the shales, though thick, being of the same age, and their inhabitants not having been subjected to any destructive change, they preserve identity in their fossil remains.

A short depression, or perhaps an accidental inundation of short duration, makes upon marshes the beginning of a formation of shales, which, if it is soon stopped by a new vegetation, produces in the bed of coal a separation or a clay parting. As these partings are formed upon the surface of a vegetable stratum, they ought to be generally on a large scale, and follow the same rules as the shales. They may also thicken, or entirely disappear, or accidentally separate into two or three branches.

The shales may be wanting, either from erosion, or from the upheaval of a part of the surface above the water, or from the more active growth of the vegetable matter in a peculiar spot. The two last causes are scarcely observed: the first and more frequent one shall be mentioned again with the sandstone. Generally speaking, the absence of the shales is local, and ordinarily, even where they seem to be entirely wanting, if the mine be worked to any extent, they are discovered in some places.

IV. THE LIMESTONE.

This formation can be regarded as a continuance, and sometimes as an equivalent, of the shales, since it is established only in an undisturbed sheet of deep marine water, by the continuous labor of marine animals, especially molluscs, and by the decomposition and accumulation of their remains. The essential reason of its formation, viz., deep, quiet, marine water, is nevertheless a cause of great variety—not in its chemical elements, perhaps, but in its persistency, its thickness, and its general distribution. It is often found in the Coal Measures in an unfinished state, in irregular masses, which can scarcely take the name of beds, so limited are they. For this reason the limestone, by its presence above a bed of coal, is scarcely a reliable guide for identification.

As long as the shales of the coal were deposited in low water, the influence of the sea, especially its currents, were scarcely appreciable. But in the limestone formation it is very visible indeed. The unequal distribution of the matter, and especially the remarkable erosions of the beds or isolated masses of it, are due to slow currents.

The limestones of the western coal-fields of America, contain a great amount of organic remains, plants, shells, or fishes. But the plants cannot give a reliable criterion for the geological level of each peculiar strata, since all the remains found till now are only broken, deformed, and undeterminable parts of stems, with few marine fucoids. The remains of shells and fishes would probably afford some reliable data for tracing the geological level of the beds of limestone. They are only too numerous in their species, and have never been subjected to a careful study. The animals of the limestone belong, evidently, to the sea, and are brought in with it. In a change of level they are destroyed as individuals, not as species. Nevertheless, after a length of time, a new invasion of the sea ought to bring with it, upon the coal-fields, other species, since its neighboring sea and its inhabitants ought to have been subjected to changes.

Thick beds of limestone, interposed in many places between beds of coal and shales, offer the most certain indications of the slowness of the oscillations in the level of the coal-fields at the time of their formation. Not only the great number of species—the myriads of animals of which the remains have been literally heaped together—but the introduction of madrepores, and their constructions, marked in the limestone strata, call for an inconceivable length of time.

V. THE SANDSTONE.

In its general appearance, thickness, and composition, this formation is the most reliable of all. A substance, of which the elements have been transported and intermixed by currents, can never be a homogeneous one, especially when these currents are abnormal, the result of a cataclysm, and have exercised their action over a very extended surface, following numerous diversified phenomena. The movements of the waters, which have brought and deposited the sand, are made appreciable not only by the nature of the strata, but by traces of remarkable erosions. In some places the immediate contact of the sandstone with the coal cannot be explained but by an erosion of the beds of shales and limestones which were extended upon it. Even the coal has been sometimes swept away, then bruised, and deposited again with the sand by the energetic action of those turbulent waters. Beds of hard

sandstone are so blackened by the broken fragments of coal and plants, with which they are intermixed, that they cannot be used for building purposes. No wonder that such mighty currents have dragged with them, and buried under heaps of sand, large trunks of trees, torn from the dry land of the shores, or from the forests of the marshes ; or that they sometimes entombed in their ponderous deposits parts of forests, which are still now found standing and petrified like the pillars of some old Babylon of trees.

From this we may conclude, that the remains of vegetation found in the beds of sandstone cannot show, generally speaking, their geological level. Beds of sandstone appear, particularly marked with the remains of broken plants. It may be that by a mighty cataclysm, immense marshes, covered with trees, have been entirely swept over, and that their remains, bruised and ground by a prolonged action of the waves, have eventually been carried and deposited over the whole area of the basin. It may be, also, that the large trunks, either standing or heaped up together, in some parts of the coal-fields, where they are found now in great abundance, bear evidence of a general and remarkable cataclysm ; and that they may thus indicate a constant geological level in their position. Some incomplete observations tend to confirm this supposition, but they are still too scanty, and need to be pursued over a wide area.

It is scarcely necessary to explain why, in the beds of sandstone, the trunks of trees are mostly petrified, preserving their general outline, and not flattened as in the coal. Not only the sand is too porous a matter to prevent entirely the access of the air, but its mineral elements have exerted a constant action on the woody matter, and destroyed it entirely, or taken its place, leaving only its outline carved like a mould in the stone. Or they have transformed it to some stony substance—either silex or carbonate of lime and spar—preserving thus partially, not only the external features, but even the internal structure of the wood, to the most delicate fibres and vessels.

It has been asked many times, why, since the sandstone is a marine formation, it does not contain any shells, any remains of marine animals? Indeed, this question would be unanswerable if we were to suppose that the materials carried by the sea had formed its bottom. This supposition is not

inadmissible. Though the depression of an immense plain near the sea-shores would take it below the level of the water, it could not raise the bottom of the sea, and spread its sand over it. But every one knows that the sea-shores are everywhere bordered by hills of sand, sometimes several hundred feet high, and extending many miles, like huge inland waves. Near the mouth of the Elbe and of the Rhine, those hills penetrate the country for hundreds of miles. The sand of which they are composed—coarse or fine—is sometimes mixed with gravel, but contains no shells or animal remains. Such sand hills have probably furnished the materials for the sandstones of the Coal Measures; at least this is to me the only satisfactory explanation of their formation and composition.

The other rocks of the Coal Measures, like the deposits of iron, under their different forms and compounds, are purely local, and have no relation to our subject, viz., the identification of coal veins by palæontology. The discussion of their formation and distribution would be out of place here.

To conclude these preliminary remarks, we need only expose, in a few words, the general rules which are drawn from them:

1st. The black shales, immediately resting upon a bed of coal, viz., the roof shales, furnish, by their remains of fossil plants, shells, and fishes, the most reliable indications for the identification of their geological level.

2d. The remains of plants give for this the best characters, since the vegetation of the coal beds was more generally and uniformly distributed on large surfaces, and since the plants, by their progressive modifications, are subject to atmospherical influence, and also to the chemical changes of the water.

3d. The geological distribution of the plants or shells cannot be modified in a sudden and striking manner at each change of level. Therefore, the presence or absence of a species in the shales may be accidental, and cannot be a conclusive evidence of a change of level, except after a long and careful examination over a wide area. The grouping of fossil species in the shales and its variations, afford a more reliable indication than the presence or absence of a single species.

This sufficiently shows the difficulty of the work of identification, in a country where a small number of beds of coal have been opened and worked, and where palæontological researches have been scarcely begun; in fact, this report is only

the introduction to an important work, which ought to be pursued with interest by every true geologist, for the history and perfect acquaintance, not only of the coal fields in their general features, but of every bed of coal in particular. But it must be said, that a collection of specimens, made only for the beauty and the great number of specimens for show, is of little use. It ought to be made with a careful record of the place, and, if possible, of the true geological level in which the fossil remains are found. And thus it may, by and by, help to solve some of the most interesting problems of the formation of the coal, viz.:

Is there any true marine formation of the coal? From long explorations pursued in Europe and in America, the writer says, contrary to many assertions, that there does not exist a bed of true marine peat, viz., peat formed entirely of fucoides and marine plants; and that he has never seen a piece of coal with evident marks of marine origin.

Have all our American coal-fields been formed in a continuous basin, or is there any local one with an appreciable difference in the flora and fauna of the shales?

Is there any trace of a permanent current of fresh water, of some river having flowed either through the coal-fields during some time of their formation, or in their vicinity?

Were the coal-fields the first land surface protruded like an island from the sea, or were they true marshes, low shores of a continent, of which the outlines had been already elevated above the ocean?

These are not the only questions that are to be answered. Besides the mere practical advantage to be derived from the palæontology of coal, there is the nature of the vegetation, its relation to the atmospherical phenomena of the epoch, its comparison with the flora of our peat formations, and also with the coal flora of other continents, and many other subjects, which open up to the geologist a most interesting field for the exercise of the mind.

ART. III.—REDUCTION OF POOR COPPER ORES IN GERMANY AND IN NORWAY.

[*From the London Mining Journal.*]

UNTIL "A Smelter" is in a position to fulfil his promise, made in the *Mining Journal* of Aug. 13, to make public the details of a process for reducing copper ores of 1 per cent. at a cost of £40 per ton of copper, I will, to keep the matter afloat, give a few particulars relative to the reduction of two different copper ores, by widely different methods, and at places remote from each other—in Germany and in Norway. In the former instance, at Linz, on the Rhine, the ores consist of copper pyrites, very much disseminated in quartzose gangue. All the ores operated upon must be carefully roasted; those which contain less than 3 per cent. in a blast-furnace 10 feet high, widest in the middle, where there is an opening for the introduction of air for oxydation, and higher up a channel by which the sulphurous gases are let into a chimney 50 feet high. When the ores contain 4 per cent., they are roasted in a reverberatory furnace, as in the heat of a blast-furnace they would slag, or smelt; roasting in heaps is inadmissible; as it is a *sine qua non* in the process that the sulphurets be entirely converted into oxyds. This is by the blast-furnace effected in a much more satisfactory manner than might be expected; the infusible nature of the matrix, and the minute subdivision of the particles of ore, preventing any tendency to slagging: 80 lbs. of small coal is sufficient to roast 1000 lbs. of ore. For roasting, the pieces of ore should not be less than from 1 to 2 inches square, else the temperature gets too high; if too fine the draft will be impeded. After roasting, the ores are ground between rollers to pieces ½ inch square, in order to present as much surface as possible to the sulphuric acid to which it is now exposed, and to facilitate its action in converting the oxyds of the metals present into sulphates. The sulphurous gases are obtained by the calcination of zinc blende, of mundic, or of copper ore, only, when the latter is employed, it smelts in the heat necessary to eliminate the sulphur, and the oxydation is obstructed. The blende is crushed into moderately-sized pieces, having been previously slightly calcined to make it brittle, though not suffi-

ciently so to decompose it, and then exposed to a high temperature in a retort furnace. Above the furnace, and heated by it, a boiler kept always full of water, delivers it into the same canal as receives the sulphurous gases from the furnace, and which conducts the mixture of air, sulphurous acid gas, and hydrous vapor into the pits where the roasted ores have been deposited. These pits are 24 feet long and broad, and 5 feet deep. Small pillars of masonry on the floor of the pit, 1 foot high, support two layers of natural basaltic columns laid horizontally, the upper layer at right angles to the other, forming a kind of false bottom to the pit; the three feet above the layer of basalt is filled with roasted ore, the coarsest pieces being put at the bottom, and the fine sand on the top. The gases from the furnace and boiler are admitted under the false sole, and ascending through the openings left by the natural inequality of the basalt columns, the nascent sulphuric acid attacks the metallic oxyds present in the ores, converting them into soluble sulphates, which are partly dissolved by the water formed by the condensation of the steam, and partly by water thrown over the ore. The solution is pumped from the space between the real and the false bottom into receivers—wooden tubs set in clay—where the copper present is precipitated by means of iron, malleable iron being preferred. The precipitate, or cement copper, is carefully washed in a circular sieve revolving in water, smelted in a reverberatory or blast furnace into "black copper," and then gathered into rosettes as usual. Green vitriol and zinc, also, are made as by-products; the reduction of the latter, however, is carried out by a different company; the mother liquor from the crystallization of the vitriol is also profitably applied in the reduction of low per cent. natural oxyds, the sulphuric acid free in the liquor having the same effect on the natural oxyds as the nascent sulphuric acid has on the artificially produced oxyds in the roasted ores.

In Norway, at Vesledalen, the ores are also roasted, but not as on the Rhine with a view to expel completely the sulphur, but to effect directly the oxydation of the sulphides into sulphates; and as the situation of the works, far inland, and at a considerable height above the sea, would make iron an expensive means of precipitation, one cheaper and easily accessible had to be found. The ore is iron pyrites, containing an uncertain quantity of copper, from a ½ to 3 per cent.

The deposit being large, the cost for mining is trifling. The ore is collected in large heaps on a layer of firewood, by means of which the superincumbent mundic is easily ignited ; it burns freely though slowly for weeks or even months, the superabundance of sulphur present acidifying much of the iron and sulphuret of copper. The oxydation continues long after the burning has ceased ; even after it has been once lixiviated the action of air and water on the calcined mass produces a further quantity of copper salts, and makes it worth steeping again. The precipitation is conducted in large tanks, the means employed being the introduction of a stream of sulphuretted hydrogen gas into the solution. This gas is economically prepared by passing carburetted hydrogen, or, rather, the produce of the combustion of pine wood, in a retort over a stratum of red-hot mundic. The evolved gases on coming together decompose each other sufficiently to produce an effective and cheap means of precipitation. The precipitate is much less pure than that obtained by means of metallic iron, and its further reduction had given rise to some technical difficulties, which were not entirely surmounted at the period of my visit to the establishment. Even then, however, the manager told me he could deliver Gahr copper at the seaport, Drontheim, at a cost, including mining, smelting, and carriage, of £20 per ton, or $15 per skippund.—*Giessen, Oct.* 13.

V' P.

Art. IV.—THE LEAD DEPOSITS OF THE MISSISSIPPI VALLEY.*—
By Prof. J. D. Whitney.

[*Extracted from the Report on the Geological Survey of the State of Iowa. Vol. I.*]

Kennedy's Lode. This mine was producing largely in October, 1856. At that time the drift had been extended in the crevice to a distance of three hundred and thirty feet from the shaft, which was one hundred feet deep. The opening was about thirty feet in height, and the crevice extended upward in the cap rock, sometimes to a distance of fifteen feet or

* Continued from page 184, No. 3, Vol. I., Second Series.

more. The galena was said by the miners to have formed, for some distance, a solid sheet three and a half feet thick: in some places the rock was undecomposed; in others, the crevice was filled with tumbling rock mixed with galena. Over a million of pounds of ore had been taken from this rich deposit in the six months preceding our visit.

LANGWORTHY LODE. This was one of the most extensive and best developed crevices ever discovered in the lead-region. It has been opened and worked in different places along a line nearly three-quarters of a mile in length; and is said by E. H. LANGWORTHY, Esq., to have produced about ten millions of pounds of ore. The crevice was irregular, sometimes expanding, for a distance of one or two hundred feet, to a width of from fifteen to twenty feet, and then contracting within narrow limits. There are said to have been usually three openings, of which the upper was the most productive, the entire thickness of the productive ground being about forty feet. This interesting lode was one of the first discovered and worked in the district, and has not been accessible in later years. We are informed that a large portion of the ore obtained from it was taken out within a length of three hundred feet.

M'KINZIE'S LODE. The mine worked by Mr. M'KINZIE for several years, but which is not now accessible, is said to have been carried to a greater depth than any other in the lead-region, having nearly reached the bottom of the Galena limestone; the deepest workings having been extended two hundred and ninety feet below the surface, as was stated to us by Mr. M'KINZIE. In the fourth opening, at the depth of two hundred and eighty feet, a mass of ore was discovered, "shaped like a counter," which weighed seventy-five thousand pounds: this is the only instance, so far as we have been able to ascertain, where any ore has been obtained in this vicinity, so low down in the rock. The opening was about three or four feet wide and six feet in height. MANGOLD's workings, near M'Kinzie's, had reached, in the spring of 1857, a depth of a hundred and seventy-three feet; but had not been found productive in the third or lower opening: the upper one was twenty-six feet in height, and from this most of the lead had been taken.

Among other celebrated crevices which have been worked in former years, and which have been noted for their productiveness, are the following:

Booth & Carter's: Cave-opening, forty feet deep, produced 3,500,000 lbs.

Kilbourn: Shallow; no cap-rock, produced 4,000,000.

North Langworthy: Produce, 3,000,000.

Ames: Two crevices; mineral to the surface and to the depth of sixty or seventy feet, produce estimated at 2,000,000

Madden: Amount of ore raised, 2,000,000.

M'Nair: Three or four parallel crevices, with very heavy masses of ore in two crevices; amount of ore raised, 2,000,000.

Dubuque cave: Worked by Julian Dubuque; supposed to have produced 2,000,000 of mineral.

Many other crevices might be mentioned; but the information in regard to them is so indefinite, that, for the present at least, it is not deemed best to attempt to give a complete catalogue, as may perhaps be done hereafter. The difficulty of procuring exact accounts of long abandoned workings is so great, that no complete history of the old mines in the vicinity of Dubuque will ever be put on record, as so many of the old miners are dead or have removed from the country, leaving no account of their work behind them.

The diagram of the lead-bearing crevices in the vicinity of Dubuque which accompanies this Report, will serve as the first attempt to bring together such information as could be procured in regard to the position of the productive lodes which have been worked in former years, as well as those which are still accessible. For much of the information upon it, we are indebted to Messrs. Richard Bonson and R. Osee Anderson; as also to H. Von Werthern, Esq., of the Surveyor General's office, who has kindly aided in the collection of materials.

Although there is indeed a surprising regularity in the direction of the crevices in this district, their parallelism being much more marked than in other portions of the lead region, the diagram must not be taken as representing them with absolute accuracy in this respect. Where the workings have been for some time abandoned, they are, in most cases, entirely or nearly obliterated; and the recollection only remains that they had the general direction of the ranges of the district, which is nearly east and west, in many instances not varying more than a degree or two from that course. It is much to be regretted that a careful record has not been preserved, by those residing at Dubuque and interested in the mines, of the position and course of all the lodes which have

been opened, and, especially, of the depth to which they were worked: the information which would be supplied by a map, based on accurate data and with correct topography, might hereafter be of the greatest importance, not only scientifically, but in its practical bearing on the interests of the mining region.

Before proceeding, however, to general considerations on the mode of occurrence of the lead ore in Iowa, it will be proper to notice what has been done in the way of mining in other districts farther to the northwest, in the direction of the outcrop of the lead-bearing rock.

The diggings on the little Makoqueta river, near Durango, were formerly very productive, having given employment to more than one hundred and fifty men at one time: they are now almost entirely abandoned, and in 1856, when this district was last visited by us, only a few persons were engaged in washing over the old rubbish. There is a very remarkable range or series of crevices, running N. 80° W., S. 80° E. for a distance of between one and two miles along the middle fork of the little Makoqueta: in this range, the indications of heavy workings may be seen on almost all the points of the bluffs coming down to the river on the south side. On the southwest quarter of Sec. 31, T. 90, R. 2 E. at Ewing's diggings, the crevice is said to have been thirty feet wide, and to have produced large quantities of lead. This locality will be noticed farther on, under the head of zinc.

There have been, in former times, some diggings in the neighborhood of Sherald's mound: those on Sherald's creek, about a mile west of the mound, are said to have been tolerably productive. Beyond this, to the northwest, we know of no mining of any importance, until we reach the neighborhood of Buena-vista. Here, in the ravine extending back from the river in a nearly southwest direction, are several excavations which were not working, when examined by us in 1857. One crevice was noticed, extending to a distance of two hundred and fifty or three hundred feet, in a direction N. 83° to 85° E., forming a square opening from which considerable mineral had been taken.

Lead is said to have been raised in some quantity, on Blubelt creek, which runs into Turkey river, from the south, near its confluence with the Mississippi, on the northeast quarter of Section 13; also on the north side of the Turkey, on

Sections 10 and 11, T. 91, R. 2. At the locality on Section 13, the crevice has been worked at intervals along a line twelve hundred feet long, to a depth of from twenty to thirty feet. The crevice is wide and regular; but the mineral does not hold in it to any considerable depth.

The next diggings of importance, and the farthest in this direction yet discovered and proved to be of any importance, within the limits of Iowa, are those in the vicinity of Gutenberg. The Galena limestone is well exposed in this region, having a thickness of nearly two hundred feet, and is very much cut up by ravines, so as to afford the best possible opportunities for exploration. The localities which have been worked are near Miner's creek and its branches, on the northeast quarter of the southeast quarter, and the north half of Section 12, T. 91, R. 3 west, and on the north half of the southwest quarter, and the southwest quarter of the northwest quarter of Section 7, T. 92, R 2 west. The workings in this vicinity are all in the flint-bed, just at the base of the Galena limestone, and from one hundred and twenty to one hundred and forty feet above the Mississippi. The mineral lies within a space from two and a half to three and a half feet in vertical height, very irregularly disseminated in the rock, from which it has to be got out by blasting. Some of the excavations were said to be three hundred feet wide, and to extend for a length of eighteen hundred feet, the roof being supported on pillars. There are no crevices extending upwards into the rock, and no "float-mineral" has been found at a higher level than the flint opening. The presence of crystallized calcareous spar, in the dog-tooth form and in very large crystals, is to be noticed as characteristic of the openings in this position. At Glenhaven, on the opposite side of the river from Gutenberg, where the workings are in a position exactly similar to that which they have at the diggings just noticed, there is a sheet of calcareous spar thirty inches in thickness, below which the Galena lies, disseminated through a stratum of rock eighteen or twenty inches thick. Some of the crystals of this mineral were six inches in length. Barytes is also found in the Gutenberg diggings, and, sometimes, in handsome crystals. These mines have produced several million pounds of ore, it is said; but, at present, they are not much worked.

Although the Galena limestone extends to the northwest

from this point for some distance, with but slightly diminished thickness, and occupying a much greater space on the surface than it does near Dubuque, we know of no crevices having been worked in it anywhere beyond Gutenberg. The position of the diggings at this place, in the lowest beds of the Galena, seems to indicate, as may be inferred from the condition of things in Wisconsin, that we are on the borders of the productive lead-region in this direction. Still, we know of no decisive reason why ore should not be found up the valley of the Turkey, either in the lower beds of the Galena or in the Trenton limestone; but the probability of the discovery of heavy deposits is, of course, diminished by the fact that, up to this time, little or nothing of importance has been found.

There are, however, some localities in the northeastern corner of the State, where galena has been mined to some extent in the Lower Magnesian limestone, and which may here be noticed. The most important deposits of lead in this rock, and, indeed, the only ones which have been observed, within the limits of Iowa, are situated in the valley of Mineral creek, a stream flowing north, through a valley lined with precipitous bluffs, into the Upper Iowa river, and about three miles south of a small settlement called New Galena: the diggings are on the southwest quarter of Section 13, T. 99, R. 6 west. In this vicinity, the Upper sandstone is well exposed on the top of the bluff, and a shaft has been sunk in it to a considerable depth. Along the face of the bluff, in which a thickness of one hundred and twenty to one hundred and fifty feet of the Lower Magnesian limestone is exposed, a number of drifts have been extended into the rock, a little below its junction with the sandstone, and considerable galena has been taken out. The limestone at this point is brecciated in its structure, appearing as if it had been partially broken up after its deposition, and then recemented: portions of the rock have also a concretionary structure, and its whole appearance is that of a material which has been subjected to both mechanical and chemical disturbances. The ore appears to be associated with irregular strings and bunches of calcareous spar, ramifying through the rock, but nowhere assuming a regular form, like that of a vein, or appearing to occupy a well developed fissure. Sometimes a little decomposition of the rock has taken place, which has given rise to a sort of opening; but none were observed which were more than a few inches

wide and a few feet long. It is said that between fifty and one hundred thousand pounds of lead had been obtained from these diggings; but it seems hardly possible that the operation should have been, on the whole, a profitable one; and, taking into consideration the hardness of the limestone, and the very limited extent to which it has undergone decomposition in the vicinity of the mineral deposits, we see little to encourage farther expenditures at this point.

The question whether the Lower Magnesian limestone contains deposits of lead ore which can be worked for any length of time with profit, is one which has, of late years, been much agitated by those interested in the mining district. For some years after the lead-region was first opened, it was generally supposed that the productive deposits of lead were limited to the Galena limestone; and Dr. OWEN gave as the result of his official examination of the country, that "when a mine is sunk through the Cliff limestone to the Blue limestone beneath, the lodes of lead shrink to insignificance, and no longer return to the miner a profitable reward for his labor. Indeed, the small quantities of lead ore which have been found in the Blue limestone occur in veins not much thicker than writing paper, which have insinuated themselves into the slender seams of the stratification." Further examinations, and the results of longer experience, have shown that this statement was erroneous, as considerable deposits of ore have been worked in the Blue limestone, although by far the largest portion of the lead of the Upper mines comes from the proper lead-bearing rock. In reference to the occurrence of lead in the Lower Magnesian, we find in Dr. OWEN's Report, published in 1852, that a number of localities in this rock are given as having yielded more or less lead ore; and, on the strength of this evidence, the formation is pronounced "lead-bearing, but whether productively so or not, cannot be fully determined until the rock is scientifically mined." Some of the localities here specified are not in the Lower Magnesian limestone, but in the Galena: the others seem, up to the present time, not to have been profitably worked. In regard to the lead deposits in the Kickapoo river, which have been much relied on by those anxious to make out the Lower Magnesian to be a good mineral bearing rock, we have learned from intelligent miners who have worked in that vicinity, that the ore lay in flat sheets in the hard limestone, and that there were no

crevices, nor any decomposed material connected with the mineral; so that the workings were uniformly abandoned after having been carried in for the short distance, beyond which atmospheric agents had ceased to operate on the rock. More recently, the occurrence of ore in this geological position, at Oleking's diggings, near Blue river, in Wisconsin, has been described by Dr. PERCIVAL, and considered by him as sufficient evidence "that the Lower Magnesian is a good mineral-bearing rock." Not having visited and examined this locality, we are not disposed to question the fact of considerable ore having been found at this place; but we are disposed to doubt the existence of mineral deposits in the Lower Magnesian, on any scale which will compare with those of the proper lead-bearing rock. Did any such exist, they would long since have been found; and a few isolated instances of lead ore obtained in this formation are not sufficient evidence of its productiveness, and much less are they to be considered as an argument in favor of the galena having originated in the igneous rocks beneath the Lower sandstone.

The most important practical questions to be asked, in regard to the occurrence of the lead in the Dubuque region, are the following:

1st. *Do the lead-bearing crevices extend indefinitely downwards, and is deep mining ever likely to prove profitable?* This question can be answered, unhesitatingly, in the negative. There is very little evidence that the crevices continue to be productive in this part of the lead-region, even as low down as the Blue limestone; and it is certain, from the study of the whole region, that they are everywhere completely cut off by the Upper sandstone. In no instance, so far as we have been able to learn, have the lodes been found to extend more than a very short distance into the sandstone, or to be productive of galena in that rock. It is true, that in some localities, ore has been found in the limestone underlying this sandstone (the Lower Magnesian), where this rock occupies the surface; but the deposits in that geological position are very few in number, and the ore limited in quantity: we have yet to learn of a single instance in which diggings in that rock have been profitable for any length of time. But, again, even if the Lower Magnesian were a good mineral bearing rock, there would be little encouragement to continue sinking from the galena limestone, through the sandstone, into the underlying

limestone; for there is no reason to suppose that a crevice, after being entirely interrupted in the sandstone, would be resumed in the limestone below, or that any other one would be hit upon, at a point exactly in the line of direction in the workings above. The fact that the mode of occurrence of the lead in the Lower Magnesian is so very different from what it is in the galena limestone is an additional reason for believing that there could be no grounds for expecting continuity in the direction of the crevices in both the rocks. A miner would be no more justified in sinking through the sandstone, in the expectation of meeting a continuation of his crevice in the Lower Magnesian, than he would be in commencing a shaft anywhere at random in this rock, without regard to surface indications, and expecting to strike a valuable lode. He might possibly find one; but the chances would be more than ten thousand to one that he would not.

There are, occasionally, instances where water is reached before the principal portion of the ore has been taken out, and where more expensive machinery than the horse-whim is required to keep the mine free. In such cases, the so-called "bull-pump" has been found very serviceable. This is an inclined wheel, from twenty-five to thirty feet in diameter, on which one or two oxen work, and which is geared to a suitable pump. With a machine of this kind, which costs about $1500, it is said that two hundred gallons of water per minute may be raised; while the expense of running it is but little more than the wages of the two men who alternate in keeping the oxen to their work, and does not exceed, with necessary repairs of the machinery, $800 per annum. The use of the steam engine may be occasionally advisable; but in the large majority of instances in which steam has been employed in this region, we are assured that the enterprise has not been found profitable. We are not aware of any instance in which the attempt has actually been made, in any part of the lead-region, to sink through the Upper sandstone into the Lower Magnesian, in order to follow a crevice through one rock into the other; but the idea has repeatedly been advocated by a certain class of persons interested in mining property, that in the execution of such a plan, great discoveries would be made, and the resources of the country developed. We believe, however, that a large majority of the intelligent miners would be willing to admit that any such operation would be a mere throwing away of money.

2d. *What can be done to farther develope the not yet discovered deposits of ore in the Dubuque district, and what method of exploration ought to be adopted for this purpose?* Is it not possible to combine capital and labor, in such a manner that results may be obtained which shall be of value to the mining interest, and which shall render the business less precarious and uncertain than it now is? There are undoubtedly extensive regions underlaid by the galena limestone, especially in Wisconsin, where rich deposits of ore are concealed by the thick covering of superficial detritus, which forbids all explorations from the surface, except at great expense. What means are there of ascertaining whether these districts may not contain valuable bodies of ore; and, if so, how may they be most economically opened and worked? To this we reply, that the proper method to be adopted will, in a good degree, depend on the situation of the locality, and the known relations of those deposits of ore in the vicinity, which have already been discovered and worked. Before any safe directions can be given, the whole lead-region must have been carefully mapped, and the crevices laid down with minute attention to their position and direction. A more or less symmetrical distribution of them will be found to prevail; and from this symmetry of the known, the position of the unknown may possibly be arrived at; but, above all things, it must be borne in mind, that in a region like the one we are now engaged with, *horizontal excavations or drifts are the proper means of exploration,* and *not vertical ones or shafts.* By sinking a shaft in a region in which the ore is distributed as it is in this district, we prove nothing except the identical spot on which the shaft is placed. By drifting, on the other hand, we can, if our drift be judiciously laid out, prove an extensive region with one excavation. Not only is this true, but it is also to be remembered, that when a shaft is sunk, we have often to encounter the difficulty of water, which is an almost insurmountable one in a region where the rocks are so cut up by crevices, which allow the flow of currents in every direction; while in running up an adit-level from a suitable position, we not only prove the country, but effectually drain it at the same time. Of course, reference is here made to explorations carried on by an association of labor and capital: as long as mining continues under the present system, there will necessarily be but little change in the methods of explorations adopted.

Let us illustrate by taking into consideration the circumstances of the region immediately about Dubuque. We have here a very large number of crevices, many of which are regularly developed, extensive and highly productive: furthermore, they are concentrated within a limited space, as will be seen by reference to the diagram of the lead-bearing crevices. If, now, by a careful series of levellings over the ground occupied by these crevices, and by ascertaining, as far as practicable, what position the productive openings had occupied with reference to the horizontal plain assumed as a base, it should be made apparent that the principal body of ore in the various ranges was approximately on the same level: then it would become a question of great interest whether an adit-level could not be carried in from the Mississippi, at the proper height to drain all the crevices which should be intersected, and at the same time to afford the greatest chance of making discoveries of ore; and whether such an undertaking might not prove remunerative, provided the many conflicting interests connected with such an enterprise could be harmonized. Let any one lay out an imaginary drift on the diagram, running from the Mississippi river, at its intersection with the line between Sections 25 and 36, to a short distance beyond the southeast corner of Section 22, and then turning nearly at right angles and extending the level, in a direction of about N. 55° E., for two miles, and he will be surprised to see how many of the most important lodes which have been worked in the vicinity of Dubuque would be intersected by an adit-level only about 5 miles in length. Still, we would not be understood as decidedly recommending a work of such a character, in this or any other part of the lead-region: such a step should only be taken after a much more thorough study of the ground than has been as yet made in any portion of the mining district. What we would insist on, is the superiority of the method of proving the country by horizontal, rather than by vertical, excavation, in a region where the body of ore is known to be within such a moderate depth from the surface.

The amount of lead produced by the mines of the Upper Mississippi has been gradually falling of, of late years, owing to the superior attractiveness of the gold fields of California, and to the fact that the larger portion of the mineral region has been pretty thoroughly explored, and the most easily dis-

covered crevices worked out. Occasionally, a very rich lode is struck by some persevering miner; but, on the whole, the number of men engaged in this business is much less than it formerly was; and some districts, which were once thickly inhabited by the lead diggers, are now almost entirely deserted by that class, the plow having taken the place of the pick and the drill.

From the records kept at Galena by Captain BEEBE and others, it appears that the amount of lead annually produced by the Upper mines gradually increased from five thousand to ten thousand tons (of 2240 lbs.), during the years from 1829 to 1839: after that it rose rapidly, and attained its maximum from 1845 to 1847, nearly reaching twenty-five thousand tons in those years. Since that time, the decline has been marked, the amount raised in 1853 being only thirteen thousand three hundred tons: since that year no exact record of the shipments has been kept, so far as we have been able to ascertain, the railroads beginning about that time to divert a part of the trade from the river. A large portion of the lead manufactured now goes across the country to Chicago, which formerly all found its way to the Mississippi. Of the remainder, a part is consumed in the country, and the rest goes down the river to St. Louis, where it is reshipped up the Ohio and to New-Orleans. If, therefore, we could ascertain accurately the amount of lead received at Chicago and St. Louis, we should have a near approximation to the entire amount produced. Such statistics as we have been able to procure, for the last few years, are given below:

Tons of Lead received,	1853.	1854.	1855.	1856.	1857.
At Chicago............	1452	1895	4449(?)	2919	?
At St. Louis...........	14248	10123	9757	6076	6347
Total from Upper mines,	15700	12018	14206	8995	

The amount given as received at St. Louis in 1857 includes the receipts from the Missouri mines, which is but an insignificant quantity.

The proportion of the produce of the Upper mines which comes from Iowa we have been unable to ascertain with accuracy. From the statements of the best informed smelters, however, it appears, that the amount of ore smelted in the vicinity of Dubuque has been about six million of pounds yielding from sixty-eight to seventy per cent of lead, in the

most prosperous year, and that it has not probably in any year fallen much below four millions; equal to about seventeen hundred tons of metallic lead, and worth in New-York city about a quarter of a million of dollars, at the current price of that metal for the last few years.

The figures given above indicate a considerable decrease in the production of lead in the Northwest during the last few years; but the diminution is not so great as would appear at first sight, since the amount required for home consumption at the West is rapidly increasing. Within the past year a shot-tower and white lead works have been erected at Dubuque, which will probably consume a considerable proportion of the lead mined in this vicinity, and supply the Northwestern States with the manufactured articles heretofore drawn from the southern and eastern cities in exchange for the crude metal exported.

The amount of lead supplied to the eastern market from the western mines is quite insignificant, the actual produce of those mines being hardly more than sufficient to meet the requirements of the West for its own consumption. Only about one hundred tons of this metal arrived in New-York from the West in 1857, the Atlantic States being now almost entirely supplied from the English and Spanish mines.

ART V.—METALLURGY OF SILVER ORES AT MANSFELD.

[*Translated from the French of M. L. E. Rivot.*]

THE mines and the smelting establishments of the different districts of Mansfeld formerly belonged to several different companies, but for many years past have been controlled by a single powerful company, which owns a vast extent of wood-land. This company has endeavored to turn to the best account the establishments already constructed, and has given economy and good direction to the metallurgi-

* *Principes Généraux du Traitement des Minerais Métalliques—Traite de Metallurgie, Théorique et Pratique, par M. L. E. Rivot, Ingénieur des mines, Professor a L'Ecole des Mines.* 8vo. Paris, 1859.

cal treatment of the ores which perhaps were formerly wanting. It has introduced improvements of great importance in the construction of furnaces, in the methods, and especially in the extraction of silver.

In studying the metallurgical treament of ores at Mansfeld, we should not lose sight of the fact that the present proprietors of the mines and establishments have been, and still are, obliged to make use of the works previously built, and only to modify them progressively without interrupting the production.

The ores are mined in many districts; Sangerhausen, Mansfeld, Eisleben, Hettstedt and Freyberg, but the works are established near the principal mines. Eight of the establishments are for melting the ores into matts only. These matts, in which the copper and silver of the ores is concentrated, are sent to the establishment at Gotteshelohnung, where the silver is extracted and the black copper, which is a residue of this operation, is melted. The black copper is carried a short distance to the establishment called Saigerhütte, where it is refined.

The minerals extracted at Mansfeld are the sulphurets of copper associated with a small and variable amount of blende, galena, iron pyrites, arsenical pyrites and ores of cobalt and nickel. These metalliferous minerals are disseminated in specks or in irregular veins in a bed of bituminous schist between walls of sandstone and compact limestone. The underlying sandstones and the walls of limestone above are impregnated with ores in many places and can be profitably mined.

The schists contain from three to five per cent. of copper and are always more or less argentiferous, containing not far from 300 grammes [11.73 ounces] of silver to the ton of schists prepared for metallurgical treatment.

The quartzose minerals of the lower wall are sometimes rich in copper, but always very poor in silver, and give by assay from two to six, and even twelve per cent. of copper.

The limestones above seldom contain more than two per cent. of copper and are poor in silver; they are mined more for their value as a flux for the quartzose and schistose ores, than for smelting.

The products of the different mines present considerable differences in their richness in copper and silver; in the pro-

portion of metallic sulphurets, blende, galena, arsenical pyrites, etc,) and in the nature of the rock in which the minerals are disseminated. These differences produce considerable variation in the processes adopted in the eight establishments for producing the matts. It is not necessary to describe in detail all the variations of the metallurgical treatment required by the differences in the nature of the ores; the three principal conditions only will be considered :—the production of the matts from the schistose ores, from the highly quartzose ores, and lastly, from the impure ores containing a large proportion of blende, galena, arsenical pyrites and of the arsenical sulphurets of nickel and cobalt.

The six establishments near the cities of Mansfeld, Eisleben and Freyberg, usually treat the schistose ores, rather pure, and containing considerable silver, which may be considered as the ordinary ores of Mansfeld.

The establishment of Sangerhausen receives very quartzose ores, rather pure, that is to say, they contain only a small portion of pyritous ores other than those of copper, and less rich in copper and in silver than those treated in the other establishments. These are the *refractory* ores

At Kupferkammerhütte the very impure ores are subjected to treatment. These contain a considerable amount of blende, galena, etc, and consequently require more numerous operations than are sufficient, at the other establishments, for the production of argentiferous matts sufficiently pure to be submitted to the processes for the extraction of the silver.

The qualities of ores delivered to the different establishments in the year 1850 are shown by the following statistics.

The establishments in the vicinity of Mansfeld, Eisleben and Freyberg received 22,746 tons of ordinary ores, averaging 47 kilogrammes (103 lbs.) of copper, and 290 grammes (about 10 ounces) of silver to the ton.

At the establishment of Sangerhausen the mines yielded 2,325 tons of refractory ores, averaging, according to assay, 30 kilogrammes (66 lbs.) of copper and 65 grammes (2 ounces) of silver to the ton.

Kupferkammerhütte received 7,640 tons of impure ores, of which the average value was 33 kilogrammes (72.6 lbs.) of copper and 130 grammes (4.1 ounces) of silver per ton.

The total production of the mines of the region of Mansfeld was 32,711 tons of ores, containing according to the assays

1,391 tons of copper and 6,843 kilogrammes of silver; say an average of 42 kilogrammes (97 lbs.) of copper and 209 grammes (85 ounces) of silver to the ton.

The country is covered with forests from which all the necessary wood and charcoal can be obtained. The price of charcoal delivered at the works varies from 41 to 43 francs per ton. Wood is dearer, in proportion, in consequence of the difficulty of transportation. It is worth 15 francs a ton. Notwithstanding the abundance, and the low price of wood and charcoal, a certain amount of coke from gas works is made use of, and is obtained from England, Silesia and Berlin, costing from 55 to 60 francs per ton. The English coke is most expensive, but appears to be better adapted to the very high furnaces.

The establishment of Sangerhausen is the only one which melts exclusively with charcoal; its distance from the avenues of communication rendering coke too costly.

The only flux used in melting for the matts is fluor spar, mined in many veins a short distance from Sangerhausen. It costs from 14 to 16 francs a ton, according to the distance of the works and the state of the roads.

Excellent materials abound for the construction of the works. The beds of sandstone below the schists afford very good refractory stone for the crucibles and the soles of the furnaces. Their prices depend altogether upon the difficulties of cutting them into shape.

Fire-brick are made in the country with clays of medium quality; they are low priced, but can only be used for the cones or shafts of the furnaces and for the roasting ovens. Irons for the fastenings, and the tools, are to be had at moderate prices. The principal workmen usually receive two francs a day. Nearly all the work is given out by the job, and the price is so adjusted that this amount is not exceeded. The uniformity in the character of the ores delivered to each establishment permits great regularity in the different operations. The day-laborers are paid from 1 franc 25c. to 1 franc 50c., according to their age and the work that they perform. The overseers and the foremen receive from three to four francs a day.

The processes may be considered under three different heads:

A, The production of the rich and pure matts containing all the copper and silver of the ores.

B, The extraction of the silver contained in the matts.

C, Treatment of the residues of the operation for rose-copper.

A, *Production of the matts.*—The number of the operations comprising this part of the treatment and the details of each of the others vary considerably with the nature of the ores. The three principal conditions will only be considered ; *a*, ordinary ores ; *a′* refractory ores ; *a″* impure ores.

a. The ordinary ores, bituminous schists mixed with a small quantity of the underlying sandstone and the overlying limestone, are roasted in great heaps, for which the bituminous matter forms the principal combustible. The metallic sulphurets disseminated in the rocks are only slightly oxydized ; the operation is more a *calcination* than a true roasting.

The roasted minerals are then melted for the production of a matt in a high furnace with coke or charcoal, and the addition of a variable portion of fluor spar. This operation gives two principal products ;—the matt and the scoria. The matt ordinarily contains from 45 to 46 per cent. of copper, and nearly 300 grammes of silver to the 100 kilogrammes, and is pure enough to be sent directly to the works for the extraction of these metals. The scoria is very poor and nearly all of it may be thrown away ; only those portions which contain granules of the matt are remelted.

a′. The refractory ores are treated in the same manner. Only the bituminous schists and the calcareous ores are subjected to roasting, and in melting, a larger proportion of fluor spar is used. The matt obtained is richer in copper, but poorer in silver than that produced by the treatment of the ordinary ores. It generally contains fifty per cent. of copper and 120 grammes (3.8 ounces) of silver to the 100 kilogrammes (220 lbs.).

a″. The treatment of the impure ores is more complex, for it is necessary to volatilize or scorify the greater part of the arsenic, zinc, lead, nickel, and cobalt, the presence of which in the matt renders the extraction of the silver very difficult. It is also necesary to scorify a part of the iron contained in the pyrites which accompanies the ores.

The ores are all roasted in great heaps, and afterwards melted for the formation of the matt in a high furnace, with additions of fluor spar in variable proportions. This first melting gives two principal products, the matt and the scoria.

The matt does not contain more than 35 per cent. of copper, and holds a large portion of sulphur and bodies which are prejudicial in the process for the extraction of the silver. The scoria is very poor in copper, and may be nearly all thrown away.

The first matt is roasted and afterwards melted in a half-high furnace with a certain quantity of the silicious scoriæ of the first melting. Two products are again obtained—the matt and the scoria. The matt is rich in copper and in silver, and at the same time pure enough to be submitted to the process of extraction. It ordinarily contains 50 to 52 per cent. of copper and 220 grammes (7 ounces) of silver to the 100 kilogrammes (220 lbs.) The scoria should be repassed the furnace, in part at least, in the first melting.

B. *Extraction of the Silver.*—Many methods have been tried, successively, for extracting the silver from the cupriferous matts, but none have yet given results altogether satisfactory, and this is the case not only at Mansfeld but at Freyberg, in the Hartz, in Hungary, and elsewhere.

The two methods most recently attempted at Mansfeld will be briefly described. These are the processes of M. Augustin and M. Ziervogel. The first, is a happy modification of an older process for the amalgamation of matts, and the second is a simplification of the first.

Method of M. Augustin.—The matts are pulverized under stamps, then ground in a mill and subjected to roasting in a double-hearth reverberatory furnace. Upon the upper hearth they endeavor to produce oxydation and the sulphatisation of the metals; upon the lower one the temperature should be sufficiently high to produce the decomposition of nearly all the sulphates of iron and of copper. Towards the end of the roasting, when it is known by the assays that the decomposition of the sulphates is sufficiently advanced, they mix in the furnace itself, and upon the lower hearth, a certain proportion of salt, and heat the matt nearly to redness. The sulphates are rapidly changed into chlorides by the action of the salt, so that the charge may be withdrawn very soon after the salt is introduced.

The roasted matts and chlorides formed are lixiviated. They are placed in large wooden vats in which a warm and concentrated solution of chloride of sodium is produced and continued. This solution is allowed to act until all the chloride of silver is dissolved.

These different operations give two products, the saline waters and the residues impregnated with the concentrated solution of salt. The saline waters contain the chloride of silver in solution, and the chlorides of all the metals found in the matts. This solution is allowed to run slowly through a series of vats or tubs, so arranged that the flow is from one to another, and furnished with stopcocks, by which the rapidity of flow from one tub to another may be regulated at will. The first tubs contain cement copper, which precipitates the silver in a metallic state ; the last contain fragments of iron, or cast iron, which precipitates the copper.

The waters charged with proto-chloride of iron are then conducted into shallow basins in which the action of the air produces precipitation of the greatest part of the iron. The clear solution is raised by the aid of a pump into an evaporating pan.

At certain intervals the silver deposited upon the copper, and the copper precipitated by the iron, are withdrawn from the tubs. The silver is purified and melted into ingots. The copper is freely washed with water, by which it is separated from the sub-salts of iron and obtained in finely-divided grains, easily oxydized. The washed cement copper is only used for the precipitation of the silver. The waters used in washing are conducted into basins, and the slime deposited from them is treated for copper at the same time as the residues of the lixiviation.

The residues contained in the dissolving tubs are washed at intervals with hot water, and are afterwards piled in heaps upon the floor of the workroom. When they have dried a little they are carried to the buildings for producing black copper. A part of the water used in washing is sufficiently charged with salt to be sent to the evaporating pans. The definite products of the extraction are thus : silver in ingots, and the cupriferous residues, containing the metals in the state of oxyds.

Method of M. Ziervogel.—This method differs from the preceding in an essential particular ; the sulphate of silver is not changed into chloride after the operation of roasting, but is dissolved, as nearly as possible, in warm water.

The series of operations is as follows :

Pulverizing and grinding the matts.

Roasting in a double hearth reverberatory furnace.

Solution of the sulphates in hot water.

Precipitation of the silver by cement copper.

Precipitation of the copper by iron.

Purification and melting in ingots the precipitated silver.

Washing of the copper precipitated by iron.

The cement in grains is used for the precipitation of the silver; the residues of the lixiviation and the sediments proceeding from the washings of the precipitated copper are dried, or rather drained, upon the floor of the workroom and sent to be treated for black copper.

The same apparatus will answer for the two methods, except the evaporating pans for the concentration of the saline waters, and the great clarifying basins, which are peculiar to the process of M. Augustin.

C. Treatment for Rosette Copper.—This last part of the metallurgy of Mansfeld comprises two operations:

c. Melting the residues of the extraction to obtain black copper.

c'. Refining black copper in a small hearth.

The first of these operations is made at the works of Gottesbelohnung; the black copper is sent for refining to the works called Saigerhütte.

c. Melting for Black Copper.—The residues are mixed with a small proportion of clay moulded into bricks, and completely dried, either in the open air, or under the shed which covers the furnaces. They are melted in half-high furnaces with sulphate of lime, pyrites, matts of the operation itself, and with sand, used as in melting oxyd of iron. The slags of the operation and those from the refining furnaces are also added.

This melting gives three principal products: black copper, the matt, and the scoria.

The black copper is sufficiently pure for refining. The matt is rich in copper but poor in sulphur, and is broken in fragments and smelted without roasting. The scoriæ are not entirely worthless: they contain a variable proportion, generally slight, of oxyd of copper, and of granules of black copper and matt. The richest are returned to the furnace in the same melting; the rest should be thrown away, for their percentage of copper is not high enough to allow them to be transported to the establishments which treat the ores.

c'. Refining Black Copper.—Black copper is refined at a

small hearth by the ordinary method. Rosettes only are produced; the scoria and the dross of refining are carried to Gottesbelohnung to be added to the melting for black copper.

DESCRIPTION OF THE FURNACES AND PRINCIPAL APPARATUS.

That the description of the metallurgy of Mansfeld may not be unnecessarily prolonged, I will not give the arrangements of establishments themselves, but only those of the principal apparatus; of the high furnace used for producing the matts; of the half-high furnace for producing black copper; of the double hearth reverberatories, in which the metals of the matts are changed to sulphates and chlorides in the two processes of MM. Ziervogel and Augustin; and of the tubs for lixiviation and precipitation.

High Furnace.—The furnaces formerly employed for melting the ores for matts have been successively replaced by true high furnaces, arranged like those of iron furnaces. I will not describe the former apparatus, and will only give the arrangement of the high furnaces constructed in the establishments which treat the ordinary and refractory ores. Those which are used at Kupferkammerhütte for the impure ores, present some modifications that I will notice in describing the operations.

The interior space is composed of four parts: the cone (*cuve*), the boshes, the hearth (*l'ouvrage*), and the crucible. The horizontal section of the two first is circular, that of the crucible is trapezoidal; the walls of the hearth form the gradual passage of the boshes to the crucible. The principal dimensions are the following:

Cone—Height, $2^{m}.80$; diameter at the mouth of the furnace, $0^{m}.78$; at the bulge, $1^{m}.42$.* *Boshes*—Height, $0^{m}.63$; lower diameter, $0^{m}.89$. *Hearth*—Height, $0^{m}.90$. *Crucible*—Mean height, $0^{m}.70$. The section at the tuyeres is a trapezium, of which the bases are $0^{m}.80$ and $0^{m}.66$, and the height $0^{m}.73$.

The blast, heated in a special apparatus, is thrown in by three tuyeres placed at the same height upon three sides of the furnace. The tuyeres are cast, and enveloped in water. The nozzles are of sheet iron, with a diameter of $0^{m}.42$.

The cone is constructed of fire-bricks; the thickness of the walls is $0^{m}.30$, while all the lower part of the furnace is of

* One metre=39.370 English inches.

sandstone. The thickness of the refractory lining increases from the throat to the tuyeres, from $0^m.30$ to $0^m.50$ at the back and the two sides ; at the breast it is $0^m.53$.

All the refractory masonry rests upon a slab of sandstone, the surface of which is inclined ten degrees towards the breast of the furnace. This rests upon a thick bed of scoriæ, and these upon a foundation of masonry. The breast rests upon a very elliptical arch of sandstone, the keystone of which is raised $0^m.55$ above the bottom stone. The front of the crucible is closed by bar of sandstone, or dam, $0^m.63$ long and $0^m.45$ high. This does not completely close the opening between the jambs and the arch that sustains the breast, but leaves an opening of $0^m.10$ on three sides. During the working, this opening is stopped with fire-clay, in which the openings are made for drawing off the slag and for running out the matts.

The furnace is charged through an opening in the cylindrical chimney which surmounts the furnace. This is connected by a platform with the roasting floors of the ores, and with the storehouses for the different materials, arranged upon the slope of the mountain against which the furnace is placed.

Half-high Furnace.—The interior of the half-high furnace presents a rectangular section throughout its height. The back wall is vertical, and the three other faces are vertical from the bottom of the crucible nearly to $1^m.25$ above the tuyere ; above this they are slightly inclined towards the interior, up to a height of $2^m.90$. The horizontal section measures $0^m.68$ by $0^m.48$ at the throat, and $0^m.92$ by $0^m.92$ at the tuyere.

The sole is brasqued,* resting, as also the sides, upon a horizontal bottom-stone of sandstone. This is placed upon a bed of scoriæ and these upon a solid foundation. The lining of the upper part of the furnace is of fire-brick, while the lining of the lower portions is of sandstone, with a thickness of $0^m.30$. The arrangements of the breast and the stoppage of the crucible are similar to those of the high furnace.

The blast enters by a nozzle of sheet iron, of which the opening is $0^m.040$ in diameter, placed in a cast tuyere, surrounded with water. The lowest point of the inclined sole of the furnace is $0^m.65$ below the tuyere. Two exterior basins also in brasque are placed before the breast and in the soil of the shop. These receive the products of the furnace alternately.

* i. e., lined with charcoal.

The interior construction is of ordinary masonry, and is prismatic. It has two embrasures, one behind the back for the tuyere, the other before the breast, giving access to the crucible. The charging is effected by the throat as in the high furnace.

(*To be continued.*)

MINING AND SCIENTIFIC INTELLIGENCE.

GEOLOGY.

On the Geology of the South-east part of Vancouver's Island. By HILARY BAUERMAN, ESQ. In the December Number of the *Lon. and Edin. Phil. Magazine*, we find the following abstract of a communication on this subject to the Geological Society of London:—

"The author described, first, the metamorphic rocks which are everywhere seen in the neighborhood of Esquimalt and Victoria, principally dark green sandstones and shales, passing insensibly into serpentine, chlorite-schist, mica-slate, and gneiss. At some places unfossiliferous crystalline limestones are associated with them. Dykes of greenstone, syenite, porphyries and trap rocks frequently penetrate the metamorphic rocks. To the westward of Esquimalt black cherty limestones and red porphyry occur. To the north at Nanaimo, rocks with Cretaceous fossils appear, also at Cornoux island, twenty-one miles north-west of Nanaimo. The fossils occur in nodules, and consist of fish scales, Nautilus, Ammonites, Baculites, Inoceramus, Astaste (?) and Terebratula. Lignitiferous deposits (sandstones, grits, conglomerates and micaceous flagstones) succeed the Cretaceous rocks, and are extensively developed over a great extent of country, forming the mass of the islands in the Gulf of Georgia as far south as Saturna island. Northward, they occur at Fort Rupert. Two seams of coal, averaging 6 to 8 feet each in thickness, occur in these beds, and are extensively worked for the supply of the steamers navigating between Victoria and the Frazer River. The coal is a soft black lignite, interspersed with small lenticular bands of bright crystalline coal. Retinite is common in more earthy portions. Shales, with plant-remains, are interstrati-

fied with the lignite. At Bellingham Bay on the mainland similar coal-bearing sandstones have been observed by the American geologists.

"A pleistocene boulder-clay is widely distributed over the southern part of Vancouver's Island, and the opposite coasts of the mainland. In the neighborhood of Esquimalt and Victoria the rocks are deeply scratched and grooved along the shore; and so also is the rock surface beneath the drift, which at Esquimalt Harbor is about 20 feet thick, while it is much more at the Barracks, and more than 190 feet thick between Albert Head and Esquimalt."

Explorations in New Mexico, Utah, and Texas.—Dr. Newberry has returned to his home after successful Geological explorations in New Mexico and Utah. Some of the results of his labors are noticed in the January number of the *Am. Jour. Sci.* as follows :—

"His collection of fossils is very large, offering conclusive evidence of the Geological structure of a very large area. Of the Cretaceous deposits he was fortunate in obtaining a peculiarly satisfactory analysis. Contrary to all our previous notions, these beds turn out to be much more largely developed, that is, existing in much greater force, stratigraphically, west of the Rocky Mountains than east of them. In southern Utah, (just where Marcou claims there are no Cretaceous rocks,) he found beautiful exposures of 4000 feet in thickness of strata of that age, with abundant fossils both animal and vegetable. The bones of a huge Saurian are among Dr. Newberry's novelties."

Devonian rocks and fossils in Wisconsin.—A private communication to the Editor of the *Am. Jour. Sci.* (Jan.) states that

"Mr. J. A. Lapham announced the discovery of rocks near Milwaukee equivalent to the Devonian, containing remains, which he exhibited, of characteristic fishes. These remains consist of fragments of bone, teeth, a paddle with portion of the tuberculated skin or osseous covering. The bed containing these remains overlies the Niagara group, and is the uppermost of the geological series yet observed in Wisconsin."

Cretaceous Strata at Gay Head, Mass.—According the *Am. Jour. Sci.* for January, Cretaceous strata were discovered during the past summer at Gay Head, by Wm. Stimpson, Esq. These beds have been regarded as Eocene by Prof. Hitchcock and others.

IRON.

Tungsten Steel—A communication on this subject from the pen of M. E. Kopp, appears in the number of the *Répertoire de Chimie* for August, 1859, from which we translate the following:—

It has been stated that cast iron containing from five to six per cent. of tungsten, accquires an extraordinary hardness. Cast steel also, containing from four to five per cent. of tungsten will have a tenacity and quality superior to those of the best steels, and will become capable of taking a most extraordinary temper and hardness. According to the trials made at Neustadt-Eberswalde, tools of tempered tungsten steel were capable of cutting objects made of ordinary cast-steel equally tempered. A tungsten steel hatchet severed a bar of iron one centimetre (0.393 of an inch) in diameter without being injured.

At the Imperial Polytechnic Institute of Vienna it was found in experimenting upon bars an inch square (694 millimetres square) that a force of 1158 quintals, (near 64850 kilogrammes,) was required to break them, which is a proof of a highly superior tenacity. These qualities render this steel valuable for the manufacture of cutting instruments, such as chisels, shears, gouges, drills, planes, &c.

For the preparation of this steel wolfran [tungstate of iron and manganese] is purified by roasting, pulverizing, and washing, and by a final treatment with dilute hydrochloric acid. The purified ore is then placed in a crucible with coal dust and heated to redness for three hours. The ore is reduced and a porous gray mass is obtained, formed of metallic tungsten alloyed with carburets of iron and manganese. This is the product which is used for the preparation of tungsten steel, and it is thrown into the crucibles in which cast steel is melted. Care must be taken before running the steel into ingots to increase the heat of the fire, for ten or twenty minutes, so as to carry the temperature of the crucible to a bright redness.

Tungsten iron may be obtained by adding purified wolfram directly to the charge in the high or cupola furnace. In this case it is necessary to use a considerable proportion of wolfram, nearly thirty per cent. of the weight of the iron. The tungsten combines so intimately with the iron that it is not eliminated by refining or puddling. The bars of tungsten iron which are thus formed can be changed to steel by the method of cementation.

It appears that the manufacture of tungsten steel, in quantity, yet presents considerable difficulties, and that it has not yet been practicable to prepare masses or bars of considerable size which are free from faults.

It is desirable that this application of tungsten should be practically established, for this would render a great service to mining industry by utilizing a material of wide distribution, which until now has been banished from the list of ores capable of profitable exploration.

The only applications of the compounds of tungsten hitherto made, and which have not had great success, owing perhaps to the qualities of the products not being sufficiently remarkable or superior to give much value, or, possibly, because the processes and preparations were too costly, are the following: use of tungstic acid for coloring yellow; oxyd of tungsten for coloring blue; and the employment of tungstate of soda in dying and calico printing, and as a substitute for stannate of soda.

Manufacture of Iron at St. Louis.—A correspondent ("Carondelet") of the St. Louis *Republican*, makes the following estimate of the cost of production of iron near St. Louis as compared with the cost at Pittsburg.

The Directors of the Iron Mountain Railroad informed me that the delivery of ore from the "Iron mountain" and "Pilot Knob" will cost no more at this point, [Carondelet,] than at "Sulphur Spring," or any other intermediate point, and captains of steamboats propose to deliver coal from "Fountain Bluff" to this point, or to the levee at St. Louis for 1½ cents per bushel, or 42 cents per ton. Now, presuming that two points be established for the manufacturing of pig metal, one at "Fountain Bluff," the other at "Carondelet," the same barges that will deliver the coal at this point will deliver the ore at "Fountain Bluff;" thus the distance between the two points would be almost annihilated.

It sets down the cost of making iron at Fountain Bluff, from the figures produced in the article published in the *Republican* of the 19th inst.:

For every description of labor around two furnaces erected adjacent to each other, we will set down the daily expense at	$80 00
Two tons coal at 150=300x32=	96 00
" " ore delivered,250=500x32	160 00
Flux and sand, 50x32	16 00
Interest, wear and tear, 150x32	48 00
Divided by 32	$400 00

Cost per ton at Fountain Bluff		$12 50
Now, presuming that we will make the same quantity at Carondelet, 32 tons daily, we will set down the cost of every description of labor at allowing $10 for daily increase of house rent, &c.		90 00
Two tons of ore on the furnace bank, $2=4x32		128 00
Two tons of coal on the furnace bank, at $2.42=4.84x32		124 00
Flux and sand, 50x32		16 00
Interest, wear and tear, $1.50x32		48 00
Divided by 32		$406 00
Cost per ton at Carondelet		$12 70
Cost at Fountain Bluff	$12 50	
Shipment to St. Louis	50	
		13 00
Half		$25 70
Average cost at St. Louis		12 85

From the above estimate it is clearly shown that pig iron can be made at Carondelet twenty cents cheaper than it can be made at Fountain Bluff, and delivered at St. Louis, and $8 05 lower than it can be made at the Clinton Furnace at Pittsburg, to which we are entitled to add the cost of transshipment from Pittsburg to St. Louis, which at the present rate is $5 per ton, which gives $13 05 per ton in favor of the article manufactured at Carondelet.

Theory of the Constitution of Steel.—Unsatisfied with the common theory of steel being made with a combination of carbon and iron, Mr. J. Saunderson, an English manufacturer of this metal, has instituted some experiments with the following results:—

1st. Wrought Iron heated in presence of carbon is not converted into steel.

2d. The transformation takes place when atmospheric air has access.

3d. Pure carbonic oxyd is without action.

4th. Ammonia or nitrate of ammonia are incapable of steeling iron.

5th. It is the same with the divers hydro-carbons employed pure.

6th. But the iron is steeled when we apply, at the same time, ammonia and olefiant gas.

7th. The transformation can be effected by pure ammonia or sal ammoniac when a carburetted iron is employed.

8th. Potassium or its vapor produces nothing, but steel is produced when ferrocyanide of potassium is used.

9th. Pure cyanide of potassium succeeds as well as the ferrocyanide; this proves that the active principle does not reside in the iron of the ferrocyanide, from which Mr. Saunderson concludes that the transformation does not take place, except with the condition of a simultaneous occurrence of carbon and nitrogen.

He adds that nitrogen is always found where iron passes into the state of steel, that it is so even in cementation that the vessels are not sufficiently tight to exclude the air, and consequently nitrogen which it contains. He recalls, on this occasion, the part played by the clippings of hides, shavings of horn and animal charcoal, which are frequently employed in the manufacture of steel. It is not obtained by dipping red-hot iron in pure olive oil, but is produced with fat—precisely because the latter is azotised, thanks to the animal membrane which it contains—whilst olive oil is free from nitrogen.—*Sci. American.*

Puddled Steel.—Puddled Steel is being extensively tried in England for steam boilers. The best qualities are as easily worked as copper, and may be one-quarter to one-third thinner and lighter than iron. So far the experiment is successful in every particular except that some makes of steel plates split and peel under the intense action of fire—others do not to an objectionable extent. This difficulty is being gradually overcome as the process is developed. For all other purposes, three pounds of steel, or less in some cases, are as good as four pounds of iron. The cost of making puddled steel and wrought iron is nearly the same. Wrought iron is made by almost wholly decarbonizing cast iron in a puddling furnace. Cast steel is made by adding carbon to wrought iron. But in making puddled steel the last-named expensive process is omitted; the cast iron is partially, not wholly decarbonized in the puddling furnace, that is, when the cast iron becomes steel, for it is always steel before it is iron, the process is stopped, leaving a product not so pure as cast steel, and dependent upon the subsequent working for its value. Such is the general nature of puddled steel; but its successful manufacture requires that intimate knowledge of the phenomena of the metal which old steel makers alone possess, and which they themselves can hardly describe.—*Am. Railway Times.*

Iron Ore and Iron from Lake Superior.—The Lake Superior *Journal* estimates the amount and value of the iron exported from Marquette in 1859 as follows:

Iron Ore, 80,000 tons	$240,000
Pig Iron, 6,500 tons	162,000
Total	$402,000

COAL.

The Anthracite Coal Trade.—We extract the following general observations from the Philadelphia *North American*, as an introduction to the annual tables * of the Anthracite Coal Trade of the United States. The figures in the table accompanying these observations in the *North American* differ slightly from those in the tables which follow, and which have already appeared in the *Mining Magazine* up to the year 1858:

During the last forty years a gigantic commerce has sprung up in Pennsylvania—not the increment of a previously existing trade, but a new, fresh, vigorous commerce, originating in the inexhaustible resources of our own, and encouraged by the immense demand of our own and neighboring States. Anthracite coal has been an article of domestic traffic only within the period mentioned, though it is now, directly and indirectly, one of the principal sources of our wealth and prosperity. Within that period millions of dollars have been invested in mining, transporting, and otherwise dealing in the anthracite coals of Pennsylvania, and thousands of industrious laborers have been remuneratively employed in the various incidental operations.

In the year 1820, the aggregate marketed product of our mines was only 365 tons. In 1859, the aggregate was 7,626,820 tons, of which three extensive and practically inexhaustible fields furnished each a large proportion. In 1820, the 365 tons alluded to were sent to market from the Lehigh region alone. In 1859, 1,628,243 tons were shipped from the same region, of which 1,050,592 tons were by canal, and 577,651 tons by railroad. The total tonnage for the period, from the Lehigh mines, is 17,748,740, of which 16,113,042 tons were by canal, and the balance, 1,635,698 tons, by railroad.

By the latter means the Lehigh region has enjoyed facilities for transportation only during the past five years. In 1855 its railroad consignments amounted to but 9,063 tons, which, regularly increasing in each succeeding year, in 1859 reached the handsome figure of 577,651 tons. This aggregate will no doubt be largely augmented in future years, as new and exhaustless beds of superior coal have been, within a few months, opened to market by the completion of the Lehigh Luzerne Railroad, which, penetrating Council Ridge, renders available some of the richest deposits of the great middle basin—those of Big Black Creek Valley included.

The Schuylkill coals first became commercially important in the year 1822, when 1,450 tons were shipped by canal. Last year 1,371,753 tons came to market by the same means of conveyance, and 1,633,150 tons by railroad, making an aggregate of 3,004,903

* The Tables will be inserted in the next Number.

tons. The transportation by the Reading Railroad commenced in 1841, in which year 850 tons were carried. It has steadily increased, with occasional fluctuations, until it has reached the amount above mentioned. Occasionally the annual railroad tonnage has been considerably larger, having, in the year 1855, a season of unusual activity, amounted to the extraordinary figure of 2,213,292. But, taking the average rate of increase, in reference to the general state of the market and the business of the country, the results of the trade, both of the canal and the railroad, are highly encouraging. Of course it is intended to refer, in this connection, only to the tonnage carried, and not to any effects of competition, either between these rivals for the same trade, or between them, or either of them, and other works supplying the same markets, upon prices and freights.

The Wyoming region is the largest, and if such a degree of comparison be admissible, the most inexhaustible of the three; but it has the disadvantage of being the most remote from Philadelphia, the great coal market of the United States. Its entire resources have not yet been ascertained; its explored deposits have hardly been touched by the miner's pick; yet it has contributed during the year just closed the large amount of 2,569,694 tons to the fuel demanded by the anthracite-consuming portions of our country. In 1829 the shipments from the region were 7,000 tons.

Number of Anthracite Collieries worked in 1859.—We have taken some pains to ascertain the number of Anthracite Collieries worked in 1859, and sum them up as follows:

	Shafts.	*Slopes.*	*Drifts or Tunnels.*	*Total.*
Schuylkill Region	4	62	47	113
Wyoming Basin	30	20	54	104
Lehigh Region		34	8	42
Shamokin		1	15	16
Total number	34	117	124	275
Above water level				124
Below " "				151

The 113 collieries in the Schuylkill Region produced 3,048,615 tons, or an average of 26,979 tons to each colliery. Last year the average for each colliery was 25,810 tons.

The 42 collieries on the Lehigh produced 1,556,912 tons, or an average of 37,069 tons to each colliery.

The 104 collieries in the Wyoming Basin produced 2,731,236 tons, or an average of 26,263 tons to each colliery.

The 16 collieries in the Shamokin Region produced 180,753 tons, or an average of 11,297 tons to each colliery.

The Lehigh Coal and Navigation Company work 8 collieries, 5 drifts or tunnels, and 3 slopes.

The Delaware and Hudson Coal Company work 14 collieries, 9 drifts or tunnels, 3 slopes, and 2 shafts.

The Delaware, Lackawanna, and Great Western Company work 8 collieries of their own, 3 shafts, 3 slopes, and 2 drifts, which produced 347,401 tons. The balance of the coal they purchase from other operators.

The Pennsylvania Coal Company work 14 collieries, 7 shafts, 4 slopes, and 3 drifts.

The collieries worked by these companies are all embraced in the above table of the number of collieries worked in 1859.—*Miner's Journal.*

Coal in the Rocky Mountains.—The correspondent of the *St. Louis Republican*, writing from Denver City, December 15th, announces the discovery of an important coal bed as follows:

After a ride of two hours and a half, we came to the coal bank. It lies on the east side of a dry creek, about twelve miles from this city. The principal vein yet opened lies in a horizontal plane, and is between seven and eight feet thick. Under this is another vein, but it is too much covered for much to be known concerning it, until it is more worked. Above the principal vein is a stratum of sandstone, sufficiently strong to form the ceiling of the mine. Separating the two veins is a stratum of shale, which is supposed by some to give way to the coal, uniting the two in one. Should this supposition prove true it will give an aggregate thickness of ten or twelve feet, and the lower edge will still be five or six feet above the dry bed of the creek.

The coal is entirely free from sulphur, or other mineral matter injurious to it, and which so frequently renders the coal of Eastern Kansas, and of Illinois, worthless, and is of that variety usually known as cannel coal. It has been opened but about two feet, but burns finely, and is considered, by good judges, to be of the very best variety. It is now owned by Messrs. D. C. Collier, N. G. Wyatt, Hiram Pierson, and C. P. Pierson. The proprietors have already commenced to work it, and will next week open a coal yard here.

The only fuel thus far used here has been a miserable quality of cottonwood. Were there a supply of coal stoves in the county, coal would soon take the place of wood. As it is, it will of necessity do so before another year, as the scanty supply of timber along the streams will soon be gone.

No better speculation could be engaged in, than that of bringing a supply of coal grates and stoves.

The coal regions of this county will undoubtedly be extensive, lying, for the most part, at a considerable distance from the mountains. For some time I had been in doubt whether any amount of coal would be found in this country, not having examined the coun-

try far back. The Cretaceous formation appears to crop out and occupy a belt about twenty-five miles wide, along the mountains, the strata curving upward toward them. The formation belonging to the Carboniferous period appears to have been worn away by the action of water, near the mountains, while at a distance from them, lying at a lower level, it retains its original position. As is well known, the Cretaceous formation supplies but very little coal. If the theory I have presented is true, coal will not be found in any great quantity at a nearer point than the bank which I have named.

COPPER.

Lake Superior Mines.—We copy the following mining intelligence from the Mining Gazette of Jan. 5th.

Quincy Mine.—No. VI shaft is down 93 feet and the width of the lode at that place is not known; it is, however, particularly rich in stamp-stuff. The upper adit comes in at about the II level. A winze between No. V and VI shafts is down 30 feet, and shows well in barrel and stamp-stuff.

The II level is being drifted south from No. V shaft, by a party of four men. It is in about 75 feet. The No. V shaft is down nearly to the III level. At the No. IV shaft preparations are being made to sink to the IV level. Parties of men are busily engaged in drifting each way from the present bottom of this shaft (III level) and have already cut through about seventy feet each way. The ground south of No. IV shaft on this level is remarkably well charged, particularly with heavy barrel work. It is one of the richest, if not by far the most rich of the many promising openings. A winze has been sunk from the II and III levels between shafts IV and V, and from the bottom of this miners are drifting in both directions. The belt is well charged in these workings, the winze showing very well. The No. III shaft is down to the III level, and preparations are being made to drift on that level in the vicinity of this shaft. The lode shows best in stamp-stuff at this place. The two winzes between shafts III and IV are nearly down to the III level. The No. II shaft is down within twenty feet of the III level. The deposit at this place has a width of sixteen feet and is rich, exhibiting small masses as well as barrel and stamp work. It being the intention of the management to put pumping apparatus in this shaft, it has been carried down the whole width of the metalliferous belt.

Between shafts II and III and on the II level two winzes have been sunk which are nearly down to the III level. It will hardly be

necessary to allude to the promise of this portion of the lode, when it is remembered that the largest single mass as yet shipped from this district, was taken from the most northerly of these winzes. But it might be added that the show still continues most encouraging.

Shaft No. I is now down nearly to the III level, and between this and No. II shaft, there yet remains forty feet to be drifted on the II level before complete communication can be effected between these two shafts.

At a distance of 1,780 feet south-west of No. VI shaft, the continuation of the belt was opened up. In the mere superficial labors about ten fathoms of ground were removed, and from this was taken out about 11,000 lbs. in quite respectable small masses and barrel work, the largest of the masses weighing about 2,020 lbs. The difference of level between this place and No. VI shaft, is two hundred and seventy feet, which, when considered, will strike our readers as affording splendid facilities for an adit, which will not only drain the mine to the 50 fathom level, but which can be driven in on the course of the copper-bearing belt, without that expense always attendant upon long adits driven through the " country " or " dead ground," and which will further, when provided with tram-ways, reduce the expenses of hoisting the vein-stuff.

Further down the hill, 120 feet above the lake, 720 feet from the opening alluded to above, another splendid opportunity is offered for driving a still deeper adit. These it must be seen are peculiar advantages, not excelled, if equalled, on the Lake, for extensively and economically working a most remarkable mineral deposit.

It is estimated that the Pewabic yields on the Quincy location, about 1,000 lbs. barrel-work to the cubic fathom, and that this itself, when metallurgically treated, will yield 50 per cent. of ingot copper.

While the underground *openings* are thus so extensively planned and equally as actively carried out, the surface improvements are to keep pace with these. On the mine at present are one 10-inch cylinder hoisting engine and two smaller ones, sufficient for the purposes of the mine this winter. But the company have contracted with J. B. Wayne & Co., of Detroit, for one of the largest and finest engines ever brought to Lake Superior. This machine is now in course of construction, and will be, as soon as the opening of navigation, brought up, and erected as soon as possible. All these advantages and improvements, combined with the extensive stamping machinery, must soon make the Quincy a representative mine of the Lake Superior mining district.

Portage.—On this location the open-cut workings on the Isle Royale Belt still continue to be actively carried on, and the deposit is still carrying the heavy copper and in the large quantities of which we before spoke. On Tuesday last some eighteen hundred pounds of small masses and barrel work, were removed, among these was one lump which we should judge would not fall far short of eight hundred

pounds weight. There are many difficulties to be overcome at this season of the year in this method of open-cut working. The men not being sufficiently protected from the inclemency of the weather, are not able to make full time.

A short adit has already been commenced and is drifted in on the course of the belt some 75 feet, and there yet remains about twenty-seven feet to be cut through before the point at which the workmen are principally engaged is reached. This will facilitate the removal of the vein stuff, which has heretofore been brought up by means of windlass and kibble, but which can now be wheeled out the adit, one man being able to accomplish what has required four men to finish. This adit will have a back of about 25 feet, which can be removed by stoping should the property be worked by a company.

Isle Royale.—The product of the Isle Royale for the month of December is larger than any we have yet reported, especially in the item "barrel-work," which alone amounts to over 16½ tons. The following is the yield:

Barrel work	33,179 lbs.
No. 1 stamp	13,107 "
No. 2 stamp	6,990 "
Masses	1,377 "
Total	54,662 lbs.

or 27 tons, 723 lbs. net weight.

The Copper sent from the Isle Royale is remarkably well cleaned; the barrel work will yield generally about 60 per cent. ingot copper; the No. 1 stamp about 95 per cent., and the No. 2 about 85. The mine is looking well, and the product for January promises not to fall behind that of December.

Mesnard.—Under date of Dec. 29, the Gazette says of this location.—The show is most encouraging, and the work is progressing finely. Drifting has already been commenced both north and south of the No. III shaft. Eight men are thus engaged in the X fathoms level, and have already drifted for over one hundred and twenty-five feet. The No. II shaft is down 30 feet, and the contract for holing it still further, is about being let.—A new shaft [No. IV] is soon to be commenced.

According to the Ontonagon correspondent of the *Gazette*, the product for November of the following mines is as follows:

Minesota	140 tons.
Rockland	35 "
National	32 "
Total	197 tons.

The "Minesota" is making some rich developments at the 90 fathoms level; they are now engaged cutting up a "mass" at that

level, over 3 feet in thickness, weighing over 60 tons, and have another "mass" also exposed at the 60 fms. level, near No. 8 shaft, much longer. The "Rockland" are opening rich ground at the 50 fms. level, and continue to find the vein improving at 40 fms. level as the work approaches the Minesota boundary. The National has fine prospects, they have one very large mass exposed, in their No. 3 shaft, and other parts of the work are very promising.

CANADIAN COPPER.—The Montreal *Witness* has seen a lot of copper, consisting of about half a ton, in cakes, from the mines on the Canadian sides of Lake Superior, being the first from that quarter. It was smelted by Messrs. Fletcher & Williams, at the Huron Copper Smelting works, Bruce Mine, from the sulphuret ore from Michipicoten, Lake Superior. We learn, also, that F. & W. have contracted to smelt the ore of the Montreal Mining Company for seven years, and Mr. Fletcher has leased the Michipicoten Mine, on royalty, from the Quebec and Lake Superior Mining Company.—*London, Can., Free Press.*

Copper Mines and Mining in Arizona.—In conversation with a gentleman who has just arrived here by the overland mail from Arizona, we have learned some gratifying particulars in relation to the copper mines and copper mining in that interesting territory.

There are on the waters of the Rio Mimbres, one of the principal streams there, four mines, some of which are known and others are believed to be very productive. One of them, the Santa Rita, has been worked now a little over twelve months, and at this time yields two tons of metal a day. The means of smelting are not very complete, but the ease which the copper is extracted is remarkable. The metal is of an excellent quality, superior to the Lake Superior, and comparing well with the best Russian. The veins of ore are numerous, and it yields about 25 per cent. of copper. This mine is owned by some Mexican proprietors. The Hanover mine has been worked rather less than a year. It shows a vein which, at twelve feet from the surface, is fifteen feet thick. This ore is very rich, yielding over 30 per cent. The daily make is one and a half tons. This mine is owned by Messrs. Hinckle & Thibault. The two others mentioned are very recent discoveries, but promise very well. In fact there is no doubt among the best informed in Arizona that copper mines of great richness and fine quality abound there, and that Arizona is destined to be as noted for its products of copper as for those of silver.

There is a good growth of timber on the Rio Mimbres; and no deficiency in the mining localities mentioned of either wood or water.

All that has ever been claimed for Arizona as a depository of mineral wealth seems on the point of being confirmed in full. The silver mines are yielding well, and recently a tin mine has been discovered.—*St. Louis Republican.*

Steam Wagon for the Gila Copper Mines.—Mr. Wilson, engineer

of the Arizona Copper Mining Company, lately passed through this city from England, where a "traction engine" or steam wagon has just been completed for the company, for the purpose of hauling ore from the celebrated Ajo mine to the coast or Gila River. This engine was built by Messrs. J. Whitman & Sons, in Leeds, and is upon Barran's plan. It was ordered for the company by Richard A. Ogden, Esq., of San Francisco. The trial of the engine, before shipment, gave great satisfaction. With a load of thirty-eight tons the engine attained with ease, a speed of five miles an hour.

Ore is now waiting the arrival of this engine for transportation to the Gulf.

If the success of this wagon equals the expectations of the owners, many other rich locations in that section may be profitably worked.

Copper Ore from North Carolina.—We learn that copper ore is beginning to go from North Carolina over the Central, and Raleigh and Gaston roads to Weldon, thence to Portsmouth, and there shipped to Baltimore to be smelted.—*S. Carolinian.*

Influence of Bismuth upon the quality of Copper.—M. Levol has ascertained by the analysis of specimens of nearly pure Australian copper of medium quality that the presence of less than a thousandth part of bismuth exerts a most important influence upon the metal The addition of this portion of bismuth to pure copper was found to destroy its ductility.—*Répertoire de Chimie*, Aug. 1859.

Large mass of Malachite.—It is reported that a single mass of malachite, (carbonate of copper,) weighing over half a ton, has been taken from the mine of Mr. Chambers in Australia, and sent to England.

SILVER.

St. Louis Silver Mining Company—Arizona.—Silver mining in Arizona is fast attracting attention from men of capital throughout the Eastern and Western States.

A company with the foregoing title has recently been organized in St. Louis, Mo., under special charter from the State Legislature.

The veins, three in number, intended to be worked are situated on a spur of the Santa Cruz Mountains, about 25 miles from Fort Buchanan, and only 4 miles from the Sonora line. The chief vein, styled the North vein, is reported to carry argentiferous galena and carbonate of lead, with traces of copper. It is said to yield from $175 to $200 worth of silver per ton. The president is James C. Hughes of St. Louis, the Secretary, D. C. Michael of the same place. We are informed that ten tons of freight, for the company, including a 12-horse power steam engine, a portable saw mill and grist mill, left St. Louis lately for Port Lavuca, thence to be wagoned to the place of operations.

Washoe Silver Ore.—Several tons of ore from this locality arrived in New York last month. A small specimen from a previous arrival examined by the editor, was found to resemble an ordinary lead ore or granular galena, mingled with grains of copper pyrites, the whole being in aspect not unlike the lead ore from Ulster county. A close examination shows the presence of grains and filaments of *native silver* pervading the mass.

The Territorial *Enterprise* of the 10th says that the California Mining Company, of Virginia, after six weeks of drifting, struck the main silver lead fifty-five feet below the surface. The ore discovered promises to rival in richness that from the original Comstock lead. Mining claims, in consequence of this discovery, had advanced 300 per cent.

Silver Ore in the Southern part of the Great Basin.—The following from the Los Angeles *Star*, is confirmatory of the opinions advanced in the January number of the Magazine upon the extent of the silver region:

A prospecting party, composed of Major Harvey, H. Mellus, Esq., and others, has just returned from the Mojave country. They bring some rich specimens of silver ore. The vein is four feet wide, and the assay of specimens from one side of it is $330 to the ton, and from the other $2,800. The company consists of five members, who held a meeting on Thursday morning, for the purpose of adopting measures for speedily commencing operations on their mine.

MISCELLANEOUS.

Remarkable Mass of Meteoric Iron.—Among the collections made by Dr. John Evans, United States Geologist for Washington Territory, is a small mass of iron, which has been examined by Dr. Charles T. Jackson of Boston, and found to be meteoric. According to Dr. Evans, the specimen was taken from a large mass which projects three or four feet from the soil of Rogue River mountain in Oregon. The part exposed is four or five feet in width and length.

The following is the result of an analysis by Dr. Jackson, communicated in a letter to the editor:

"Specific gravity of the pure metallic mass 7.8334; 10.7 grains yielded:

Iron	89.000
Nickel	10.290
Tin and a little Silica	0.729
	100.019

"Nitric acid produces on a polished surface the usual Widmanstatian figures." "It resembles the Siberian Pallas meteorite, and like it contains large crystals of chrysolite, the cavities left by them being as large as filberts."

This remarkable meteorite is only 40 miles from Port Orford, and could be got for shipment without great expense. Dr. Jackson has urged its removal to the Smithsonian Institution at Washington; this might be readily accomplished by the aid of a small appropriation, or through the War and Navy Departments. It should be immediately secured, either for the government collections, or for a great museum of Natural History in California, which we hope will soon be founded.

Tin Ore and Vein in California.—In the last number of the Magazine we noticed the discovery of tin ore from California. We have since received a letter from Dr. Jackson of Boston, giving the following interesting details:

"In July I received among a lot of ores, brought me under the supposition that they were of silver, a very rich *tin ore* containing 60½ per cent. of metallic tin in the state of oxyd of tin, mostly amorphous, and mixed with brown oxyd of iron. It is a curious ore, and would, were it not for its great density, be mistaken for an ore of iron. It was found near Los Angeles, California. The vein is said to be 6 or 8 feet wide. This I think must be an exaggeration,

but it is certainly eight inches wide, as shown by the size of the specimens sent to the Revere Copper Company in Boston, most of which Mr. Alger obtained for his cabinet, and for the manufacture of some samples of metallic tin, which he has smelted and refined at a brass-foundry, and got 40 per cent. of refined tin." We understand that parties have gone to California to make arrangements for opening and working this vein.

Melting Zinc by means of Gas.—A report has been made to the society for the encouragement of National Industry [France] upon the method of melting zinc by means of ordinary illuminating gas, proposed by M. Miroy. The results are interesting to zinc founders, type founders, and those engaged in melting and casting tin, lead, or the fusible alloys of these metals. We translate the following from the report:

The melting of zinc, which is generally made in crucibles of plumbago, and in a coke or coal fire, involves a very elevated temperature, difficult to regulate, and a consequent loss of metal by volatilization and combustion. The metal also acquires bad qualities, which workmen attribute to its being burned or scorched, but which appear to be due to the mechanical penetration of the oxyd of zinc into the pores of the metallic mass. The melted metal then presents a pasty consistence, and the action of the chisel and the file becomes more difficult upon the casting, owing to the alteration of the malleability.

To remedy these disadvantages M. Miroy fuses zinc by gas. His apparatus consists of a crucible of cast iron which may contain 30 to 35 kilogrammes of zinc. This is placed in a cylindrical furnace of conical form, where it is exposed to the combustion of ordinary illuminating gas, which enters obliquely on two sides by two tuyeres. These are each concentric with larger tuyeres through which air is forced by means of a blower driven by the machinery of the establishment. The interior diameter of the smaller, or gas tuyere, is 18 millimetres; those of the air, 7 centimetres. The volume of air employed has not been determined, but is estimated to be to that of the gas as 3 to 1. The inventor thinks that by this method zinc may be melted more rapidly and cheaper than by coke, while the heat may be so regulated as not to injure the metal. There is also a great saving in the cost of crucibles.—*Répertoire de Chimie*, Aug. 1859.

Borax and Saltpetre in Chili.—The Peruvian Government has just granted Gamboni & Co. an exclusive privilege, for fifteen years,

for the production of borax, as it is found about Iquique, combined with lime and soda, in great abundance.

The exports of saltpetre from that port during the past eleven months of the year have risen to almost a million and a-half quintals, averaging about two dollars in price. The export of this article has increased fully 25 per cent. over and above that of 1858.—*Times.*

Improved Safety Cage.—The improved apparatus for extracting coals and minerals from mines, which forms the subject of an invention specified by Lieut. Col. Demanet, of Brussels, is composed of two strong iron screws, which extend from the bottom of the shaft, where they turn in steps, up to the surface of the ground, where their upper extremities are set in bearings in a head frame, in which they are capable of turning freely. The upper extremities of the screws are provided with pinions, taking into a large toothed wheel mounted between them on the shaft of a horizontal wheel, which is driven by a crank rod actuated by a steam-engine. By this means the two screws will have rotary motion communicated to them in the same direction. Upon these screws are mounted two platforms, provided at each of their extremities with a strong female screw, through which the long vertical male screws pass. These platforms form the top and bottom of a cage, which may be divided into several compartments by horizontal partitions, upon which are to be placed trucks or boxes containing the coal, ores, or minerals. By this arrangement it will be seen that on rotary motion being imparted to the screws in one direction, the cage will be raised with its charge, and will be lowered on the screws being made to rotate in the contrary direction. It will also be understood that the speed to be imparted to the cage may be increased or diminished, either by increasing or diminishing the pitch of the long male screws, or giving them greater or less speed. In order to prevent the screws from bending or twisting, they are supported by spring-holding clamps fixed firmly at certain distances to the sides of the shaft, which are made to open to allow of the passage of the cage by the following means:—At the extremity of each female screw of the platform is fixed an iron bar, which is wedge-shaped, and extends a little beyond the cage both at top and bottom. The spring-holding clamps are formed of two arms, between which the side bar is made to enter on the ascent or descent of the cage; by this means they will be made to open, and are held in that position during the passage of the bar or cage, but as soon as the cage has passed the clamps they will again close upon the screws. Two sets of apparatus may be set side by side, and united by means of a connecting rod on the eccentric wheels, so that one apparatus may raise a full cage and the other lower an empty one at the same time. For this purpose, when two apparatus are thus worked together, the thread or worm of one pair of screws must be set in a contrary direction to that of the other pair. The apparatus may be also employed for raising and lowering workmen, as it offers great security.

BOOKS AND MINING REPORTS RECEIVED.

Engineering Precedents for Steam Machinery, embracing the performances of Steamships, Experiments with Propelling Instruments, Condensers, Boilers, etc. By B. F. Isherwood, Chief Engineer U. S. Navy. Vol. II., 8vo. pp. 231. Baillière Brothers, 440 Broadway, New York.

This volume is the second of a series containing papers relating chiefly to Boilers and Fuel, being, in part, accounts of experiments ordered by the U. States Navy Department, and made by Boards of Naval Engineers, of which the author was a member. The Reports which were presented to the Department have been re-written, added to, and illustrated, and are now presented in a more convenient form for reference.

The first paper describes the experiments made at the New York Navy Yard to determine the comparative evaporative efficiencies of the hard or true anthracite, the Trevorton semi-anthracite, and the Cumberland semi-bituminous coals; the three kinds in general use for steam vessel and land engines on the Atlantic coast of the United States. The papers which follow are upon the use of steam expansively, and upon boilers of different constructions.

The work abounds in valuable tables, and is well illustrated by engraved lithographs.

A Geological Visit to the Virginia Copper Region. By Richard O. Currey, A. M., M. D. 8vo. pp. 64, with Map and Section. Knoxville, Tenn., 1859.

The Gold Placers of the Vicinity of Dahlonega, Georgia. Report of William P. Blake and of Charles T. Jackson, M. D., to the Yahoola River and Cane Creek Hydraulic Hose Mining Company, &c., &c. 8vo. pp. 64. With 3 maps. Boston, 1859.

Report of Prof. Charles Upham Shepard on the Ducktown Copper Region and the Mines of the Union Consolidated Company of Tennessee. 8vo. pp. 8. Charleston, S. C., 1859.

Reports of Professor Emmons and Professor Darby, together with other matters relative to the Glade Gold Mines, Cass County, Georgia. 8vo. pp. 16. Montgomery, Alabama, 1859.

Prospectus and Report of the Terra-Nova Mining Company [*Copper*] *Newfoundland.* 12mo. Boston, 1859.

Preliminary Report on the Geology of Vermont. By Edward Hitchcock, State Geologist. 8vo. pp. 16. Montpelier, 1859.

AMERI AN MINING SHARE LIST.

This list we shall extend from time to time, until it includes, so far as practicable, every existing Mining Company whose stock is offered, or is likely to find sale in the market. As it is desirable that it should be correct, we solicit the co-operation of officers of Mining Companies.

Mining Company.	Office at	Location of Mining Operations.	Shares.	Paid in.	Present price.
Adventure, copper,	Pittsburg, Pa.,	Michigan,	10,000		
Arizona Land & Mining Co.	Providence,	Arizona,	....	....	$10 00
Aztec, copper,	" "	"	20,000		
American, coal,	New York,	Maryland,	60,000	$25 00	
Beaver Meadows Coal & R.R. Co.	" "	Penn.,	....	50 00	
Bohemian, copper,	Philadelphia,	Michigan,	20,000	....	2 37
Buck Mountain, coal,	"	Penn.,	....	50 00	
Central, copper,	Pittsburg, Pa.,	Michigan,	20,000	1 35	8 25
Copper Falls,	Boston,	"	20,000	20 00	
Cumberland, coal,	New York,	Maryland,	50,000	50 00	11 50
Dauphin Coal & R. R. Co.,	Philadelphia,	Penn.,	....	50 00	15 00
Delaware and Hudson, coal,	New York,	"			93 00
Eureka, copper,	" "	Tenn.,	10,000	50 00	
Evergreen Bluff Co,		Michigan,	20,000		
Flint Steel River,	New York,	"	20,000	4 00	3 00
Fulton, copper,	" "	"	20,000		
Forest Improvement Co.,	Philadelphia,	Penn.,			
Fond du Lac Mining Co.,	Superior, Wis.,	Wis.,	50,000		
Franklin, copper,	Boston,	Michigan,	....	4 50	22 50
Gogebic, copper,		"	20,000		
Gold Hill Co.,	New York,	N. C.,			
Hiwassee, copper,	" "	Tenn.,			
Huron, copper,	Boston,	Michigan,	20,000	4 50	3 00
Hazelton Coal Co.,	Philadelphia,	Penn.,			
Isle Royal, copper,	Washington, D. C.,	Michigan,	20,000	11 10	6 50
Lehigh Coal & Nav. Co.,	Philadelphia,	Penn.,	....	50 00	
Locust Mountain,	"	"			
Lykens Valley, coal,	New York,	"	....	50 00	
Lykens Valley R. R. & Coal Co.,	" "	"	....	20 00	
Mass. Mining Co., copper,	Pittsburg,	Michigan,	20,000		
Minesota, copper,	New York,	"	20,000	3 50	71 00
Merryweather, copper,		"	20,000		
Mesnard					6 25
Metropolitan,		"	20,000		
National, copper,	Pittsburg,	"	10,000	11 00	36 00
New Jersey, zinc,	New York,	N. Jersey,	....	12 50	
North American, copper,	Pittsburg,	Michigan,	10,000	30 00	10 00
New Jersey, Franklinite,	New York,	N. Jersey,			
Norwich, copper,	" "	"	20,000	11 00	1 00
North West, copper,	Philadelphia,	Michigan,	10,000	19 83	
North Western, copper,	Pittsburg,	"	9,000		
Nebraska, copper,	Detroit,	"			
Pittsburg & Boston, copper,	Pittsburg,	"	20,000	....	72 00
Phœnix Copper Co.,	Boston,	"	10,000		
Pennsylvania, coal,	New York,	Penn.,	50,000		
Pewabic, copper,	Boston,	Michigan,	....	3 75	50 00
Pontiac copper					4 50
Portage Mining Co., copper,	Detroit,	"	20,000		
Quincy Mining Co., copper,	"	"	8,000	9 00	32 00
Ridge Mining Co., copper,	Pittsburg,	"			
Rockland, copper,	New York,	"	20,000	2 00	30 00
Santa Rita, Silver Mining Co.	Cincinnati,	Arizona,	....	....	20 00
Sonora Exploring & Mining Co.	New York,	"	20,000	....	50 00
Sopori Mining Co., Silver,	Providence,	"	....	....	10 00
Southern Gold Co.,	Boston,	Georgia,			
Springfield, copper,	Baltimore,	Maryland,	100,000	5 00	
Superior, copper,	New York,	Michigan,	20,000	2 00	3 25
Toltec,	Boston,	"	20,000	17 00	2 75
Westmoreland, coal,	Philadelphia,	Penn.,	40,000	12 50	

THE

MINING MAGAZINE

AND JOURNAL OF

GEOLOGY,

MINERALOGY, METALLURGY, CHEMISTRY, AND THE ARTS IN THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

MARCH, 1860.

ART. I.—METALLURGY OF SILVER ORES AT MANSFELD.

[*Translated from the French of L. E. Rivot.*]

Furnace for Roasting, and for Chloridizing.—The reverberatory which serves for roasting the matts, and forming the chlorides, has two hearths, or soles, one above the other, each of which has its separate fire; but, ordinarily, the upper sole is heated only by the gas which proceeds from the lower furnace. The collecting and condensing chambers are placed above the furnace, the gas from below traversing them before passing into the chimney. The following are the principal dimensions of the lower furnace: *fire-place*, $0^m.50$ by 2 metres; *ash-pit*, $0^m.70$ high; *grate*, $0^m.25$ below the bridge; *flue*, for the flames, $0^m.20$ high; *fire-bridge*, 2 metres broad by $0^m.35$ long. The *sole*, is $2^m.60$ long, by $2^m.60$ in its greatest breadth, but recedes near the flue (*rampant*,) to about $0^m.70$. It is flat, horizontal, and constructed of fire-brick. The greatest height of the arch above, is $0^m.50$. A single door, in the middle of one of the sides and on a level with the

[* Continued from February Number.]

sole, serves for manipulating the charges. The *rampant* is very short, and is only $0^m. 20$ in height. The chimney, by which the gases and products of combustion pass to the upper furnace, measures $0^m. 20$ by $0^m. 70$, and is in the middle of the bridge.

The second furnace is arranged like the first. The bridge is longer, being $0^m. 50$. The sole is a little longer near the rampant ($1^m. 25$). The rampant is $0^m. 60$ long by $0^m. 30$, in the direction of the length of the furnace. The chimney which conveys the gases to the chambers above is $0^m. 30$ by $0^m. 60$, and vertical.

The four condensing chambers have the same height, $1^m. 45$, and the same depth, $2^m. 60$; the two first are $0^m. 60$ in length, and the two last are larger, one being $1^m. 25$, and the other $1^m. 50$. The openings between are so arranged as to cause the gases to circulate in each chamber. These openings are $0^m. 40$ by $0^m. 60$. The rampant has the same dimensions, $0^m. 40$ by $0^m. 60$. The chimney is 8 metres high, and $0^m. 50$ on each side.

The interior walls of the furnace and chambers are formed of fire-bricks; the outer masonry is of sandstone, and the fastenings are of wrought iron.

Vats for Dissolving the Chlorides.—The vats or tubs, in which the solutions of the chlorides in Augustin's process, and of the sulphates in Ziervogel's, are nearly cylindrical, and made of wood. Their height is $1^m. 42$, and the inside diameters are $1^m. 25$ and $1^m. 30$. A filter is placed at the bottom of each, composed of branches of willow, or birch, and rests on a wooden grating $0^m. 06$ above the true bottom. The slender branches are covered by a strong cloth, the edges of which are pressed tightly against the sides of the vat by a wooden hoop. A faucet placed below the grate allows the solution to be drawn off into a wooden trough, which leads to the precipitating vats. Each vat is mounted on a little car, running on rails level with the floor of the room.

Vats for Precipitation.—The precipitating vats are of wood, smaller in size, and more conical than the preceding. Their height does not exceed one metre, and the interior diameter at the base is $0^m. 55$, and at the top $0^m. 85$. The bottom is arranged as in the vats for solution, but the upper portion is divided into two compartments by a partition of wood, which bears strongly upon the filter. The greater of

the two compartments occupies nearly three quarters of the space of the vat. Both receive the cement copper or the old iron intended for the precipitation of the silver or the copper. The faucet, by which the liquid is drawn off, opens from the second compartment at nearly half the height of the tub.

Arrangement of the Vats.—The vats for solution filled with the roasted matts in which the chlorides have been formed, are placed in the same line upon an elevated stage or floor in the room. A wooden trough extends above them, by which they are supplied with hot and concentrated brine. Below the faucets, inclined wooden troughs are placed, by which the solution of the chloride is run off into two large vats, one metre high and two in diameter. The solutions are conveyed to the bottom of these vats, by pipes at the end of the troughs, and escape by faucets near the top, from which they are allowed to flow into the precipitating vats. These vats are disposed in six series, of four each, so placed that the solution shall flow from one to the other. The two upper vats are filled with cement copper, and precipitate the silver; the two lower vats contain the iron for the precipitation of the copper.

[Having already given a translation of the general outline of the metallurgical processes for the production of the matts, the descriptions in detail are omitted, and we pass at once to the consideration of the operation for the extraction of the silver.]

EXTRACTION OF SILVER FROM THE MATTS.

I have not been able to obtain more than the results of experiments upon the two processes of Augustin and Ziervogel. The figures which will be presented, will only imperfectly show the cost which these two methods entail when regularly followed. They will not even allow a rigorous comparison to be made, for the principal element, the loss in silver, is not exactly determined. The cost of extraction by the ton of matt, and by the ton of ores will, however, be calculated, in order to give at least a general view of the results obtained at Mansfeld, in the treatment of silver ores of low percentage. The method of extraction proposed by Augustin,* comprises three series of operations.

* This method is now employed at Freiberg.

1st. Stamping and grinding the matts ; 2d. Roasting and forming the chlorides by the dry way ; 3d. Solution of the chloride of silver, and precipitation of the metal.

First Operation.—The matts are first crushed by stamps, without water, then reduced to an impalpable powder between two millstones. This powder is then bolted, by which a small portion of grains of copper are separated. These grains contain silver, which is necessarily lost, as they are not in sufficient quantities to justify a special treatment. It is consequently very important that the matts designed to be treated for silver should not contain grains of copper, or, at least, but a very small proportion.

It is not necessary to enter further into the details of this first operation, which does not present any difficulty, but requires constant and careful attention. The cost of crushing and grinding is estimated at five francs per ton of matts.

Second Operation.—Roasting and the formation of the chlorides are two very delicate operations, which are effected one after the other in the same furnace. The matts contain sulphur, silver, copper, iron, and a variable proportion of lead, zinc, nickel, cobalt, and arsenic. We will now suppose that the matts are without arsenic, the bad effects of which will be subsequently considered.

The end to be attained is the transformation, as completely as possible, of the silver into chloride, which is afterwards to be dissolved in a warm liquor, containing a large quantity of common salt.

The only agent for forming the chloride that can be economically employed, in the dry way, is common salt, or chloride of sodium, more or less pure. This is without action upon metallic silver; it acts only by double decomposition upon a salt of silver; and the only one that can be economically formed, is the sulphate, by properly roasting the matts.

Roasting then precedes the formation of the chlorides, and should be conducted so as to produce the complete sulphatization of the silver. All the metal which is not changed to sulphate, is found in the roasted matts in a metallic state, escapes the action of the chloride of sodium, and is consequently lost in the extraction.

To attain this first result in the presence of a large amount of metals,—the oxyds of which have, for the most part, a great

affinity for sulphuric acid,—it is necessary to commence the roasting at a very low temperature, with a free access of air. The agglomeration which renders the oxydation incomplete is avoided, and the formation of sulphuric acid, and of peroxyd of iron, is facilitated as much as possible; but at the same time, sulphates of all the metals existing in the matts are produced.

The chloridizing agent should not be made to act upon this mixture of all the sulphates; its action being equal upon all, it would be necessary to use a large proportion of salt to ensure chloridizing all the silver; it would also require a long time to complete the action. The chloride of silver is somewhat volatile; the chlorides of sodium, iron, copper, and zinc are still more so, and these chlorides in volatilizing, would carry with them a large proportion of silver. Finally, in the following operations of solution and precipitation, there would be in the saline liquid not only the chloride of silver, but a large proportion of chlorides of all the other metals. Many of them, principally those of iron and copper, interfere with the precipitation of the silver by the copper; for copper reduces the perchloride of iron and the chloride of copper, to the state of protochlorides, before completely precipitating the silver. It is then essential to decompose, by heat, the sulphates of iron and of copper formed by roasting at a low temperature. There are then two periods of roasting; the first for producing the sulphates, the second, for decomposing the useless or hurtful sulphates.

In the first, it is easy to obtain the complete oxydation of the metals contained in the matt, and the transformation of nearly all the sulphuret of silver into sulphate, by operating upon small charges, and taking care that the workmen bring all parts of the matt successively to the same temperature, and in contact with the oxydizing gas, by almost continuous working with the rake and spatula.

The second period, the calcination, presents greater difficulties, and the desired result is never fully obtained. In a laboratory, and in operating upon a small quantity, the sulphate of silver may be preserved, while by a prolonged cherry-red heat the sulphates of iron and of copper may be entirely decomposed; those of zinc, of nickel, of cobalt, are but partially decomposed at this temperature, and sulphate of lead resists better than sulphate of silver. The principal condition of suc-

cess is, that all the mass operated upon shall be at the same temperature. In a reverberatory furnace this condition cannot be realized, the heat is always highest near the bridge; and it is necessary, in order that the charge shall be all equally heated, that the workmen should bring to the bridge, in succession, all those portions which were far removed from it at the commencement of the operation, and to repeat this, until the furnace is carried to a sufficiently high temperature.

At the hottest point, near the bridge, the heat should not exceed a cherry-red, above which sulphate of silver is decomposed. It is therefore always necessary to be careful, towards the end of the operation, that the workmen, in charging the fire, do not heat the furnace above the proper point. The calcination should be stopped before the sulphate of copper and basic-sulphate of iron is fully decomposed, for fear of decomposing a part of the sulphate of silver.

When the roasted matt is at a cherry-red heat, and gives off but little sulphuric acid vapor, trials are made of the charge, according to the progress of the decomposition. For this purpose, small quantities are taken, and while still hot thrown into water; a blue color shows the existence of undecomposed sulphate of copper; the calcination is then arrested. When the blue coloration of the water is hardly perceptible, it shows that but little sulphate of copper remains to be decomposed. The calcined matt, at this juncture, should contain nearly all of the silver in the state of sulphate. It contains, also, a small proportion of sulphate of copper, basic-sulphate of iron, and a variable quantity of sulphates of lead, zinc, nickel, and cobalt. The greater part of the iron and copper, and a small part of the other metals, are in the state of oxyds.

As soon as the calcination is completed, the process of chloridizing is commenced. The first difficulty which presents itself, is the mixture of the salt with the matt, which is at a red heat upon the bottom of the furnace. The chloridizing, that is to say, the double decomposition of the sulphates by an alkaline chloride, cannot be complete, if all the materials are not intimately mixed. The salt cannot be introduced alone, because it would melt before the workmen could have time to commingle it with the charge. Neither is it possible to allow the furnace to cool down to a low red heat, a temperature at which the intimate mixture of the salt with the matt can be easily made, for there is not only a loss of time and fuel,

but it would be necessary to again raise the heat to redness—the temperature necessary for the reactions—and during this re-heating, the loss of silver by volatilization of the chlorides would be very large. The means of avoiding these difficulties was at length found. The salt previously melted and pulverized, is mixed beforehand with a portion of cold, calcined matt, and in this state can be very quickly mixed with the hot matt upon the bottom of the furnace. It quickly becomes heated, but does not reduce the temperature of the furnace below the point necessary for the reactions.

The chloridizing can be completed in a short time, which is indispensable, so as to diminish as much as possible the loss by volatilization. The loss depends, in part, upon the care given by the workmen to the different phases of these complex operations; and partly from the chemical composition of the matts. The causes of loss are very numerous; those only which have the greatest influence upon the results of extraction will be noticed.

We may consider the silver which exists in the metallic state in the chloridized matts, and that which is volatilized as chloride during the last part of the operation,* as lost.

The silver remains in the metallic state when the workman has pushed the calcination too far, and thus caused the partial decomposition of the sulphate of silver, or when the matts did not contain sufficient sulphur to produce sulphates of all the metals. It is well to observe upon this subject, that in the double-hearth furnaces in use at Mansfeld and Freiberg, the sulphuric and sulphurous acids, which are given off during the calcination upon the lower hearth, contribute to form the sulphates upon the upper hearth. Under these conditions, the proportion of sulphur contained in the matts at Mansfeld, nearly 20 per cent., appears to be more than sufficient, when the roasting is slowly conducted.

The loss by volatilization of the chloride of silver is always greater when the heat is too high, and too long continued during the process of chloridizing, and when the proportion of volatile chlorides is large. The chlorides of sodium, of iron and of zinc, are the most volatile; those of lead, nickel, and of cobalt, are less so.

The proportion of salt which it is necessary to use, and the

* In the condensing chambers a part only of the volatilized chloride of silver is recovered.

time required for completing the formation of the chlorides, depends upon the quantity of the sulphates. For the matts of known composition, the care bestowed upon the calcination greatly influences the proportion of sulphate of iron which remains undecomposed. The greater this proportion, the greater quantity of salt it is necessary to use, and the longer the heat must be continued. The chloride of iron being very volatile, the loss of silver is greatly increased by its presence, and that of the chloride of sodium in excess.

The ability of the workman, however, has little influence upon the great loss of silver which is known to attend the treatment of matts containing zinc. Sulphate of zinc is so easily formed, and is so difficult to decompose, that it nearly all remains unchanged at the time of chloridizing. Its presence makes it necessary to use an excess of salt; the loss of silver is inevitable, and is due to the eduction of the chloride of silver by the chlorides of sodium and zinc.

The presence of the sulphates of copper, lead, nickel, and cobalt, also increases the loss of silver, making it necessary to employ more salt in chloridizing. The chlorides of these metals are, however, less volatile than those of zinc and iron, and their influence is not so great.

Arsenical Matts.—The treatment of matts containing arsenic and antimony will now be considered. It has been shown that the roasting of the matts should be commenced at a low temperature, in the presence of an excess of air, in order to facilitate, as much as possible, the formation of the sulphates. Under these conditions, it is impossible to drive off more than a small part of the arsenic as arsenious acid, nearly all remains in the roasted matt, forming arseniates which cannot be decomposed by heat. It is therefore necessary, in chloridizing, to use a large proportion of salt, and to continue the heat for a long time, so that the double decomposition of the arseniates by the salt may be nearly complete. A very considerable loss of silver results by volatilization, consequent upon the excess of chloride of sodium, and of the metallic chlorides, principally chloride of iron, resulting from the decomposition of the arseniates, and also from the long time which the chloridizing requires. This, however, is not the only injurious effect of arsenic in the extraction. The chloridized matts contain nearly all of the arsenic acid in the state of arseniate of soda.

When, in the following operation, the attempt is made to dissolve the chloride of silver in the saline solution, the arseniate of soda decomposes the metallic chlorides, and again forms arseniates, which are completely insoluble in the presence of chloride of sodium. When the arsenic is in small quantity, it may be hoped that the great affinity of peroxyd of iron for arsenic acid will preserve the silver, in part, from precipitation; but it is not at all certain, for the arseniate of silver is as completely insoluble as those of peroxyd of iron and the other metallic oxyds, in the presence of a warm and concentrated solution of chloride of sodium.

Matts highly charged with arsenic will yield very little silver by Augustin's method. A large part of the metal is volatilized during the chloridizing; another part remains insoluble in the state of arseniate in the cupriferous residues.

The matts of Mansfeld contain, in general, very little arsenic. Arsenical pyrites is not found to exist in a notable proportion, except in the impure ores, treated at Kupferkammerhütte, in which the treatment for producing the matt, in four operations, has the effect to expel the greater part of the arsenic.

Description of the Operation.—The work is conducted in double-hearth furnaces already described. One of the soles serves for roasting and chloridizing, and on the other, the matts are prepared, which, after cooling, are to be mixed with the salt. The salt is previously melted in a great cast-iron boiler, fitted with a movable cover of sheet iron. After fusion, it is pulverized upon a cast-iron plate, and then stored in well closed wooden boxes.

The entire operation is divided into three periods; sulphatization, calcination, and chloridizing. The two first are conducted in the same way as in the preparation of roasted matts intended to be mixed with salt, after cooling, previous to the operation of chloridizing. It is only necessary to describe the work of the latter.

The upper sole serves for roasting and for sulphatization; upon the under sole, the decomposition of the sulphates, and the chloridizing, are effected.

The work upon the two soles requires two men, one for roasting, and one laborer under the direction of the overseer of the department of extraction. The different materials are carried to the furnaces upon wheels.

Upon the upper sole they charge 225 kilogrammes, spread it with a rake, and allow it to heat during an hour. It is necessary, every half hour afterwards, to change the surface, and move the charge from place to place by bringing near the bridge the parts which were near the rampant. The workman uses alternately a many-toothed rake and a spatula. As the charge is small relatively to the surface of the sole, the thickness of the matt is very slight, and the roasting is easily effected.

The oxydation is nearly complete four hours and a half after the charging, but it is necessary to wait for the completion of the operation on the lower sole before the charge can be passed down. When the charge has been withdrawn from the lower furnace, the roasted material above is allowed to fall through a rectangular opening situated near the door, which is closed by a plate of cast-iron during the operation.

The roasted matt is spread upon the lower sole by a rake, and is allowed to heat slowly for half an hour. They heat, afterwards, by degrees, so as to carry the furnace to a bright redness in the space of two hours. The heat is then kept at this point for about two hours. During all this time, the workman works alternately with the rake and the spatula, endeavoring to expose all parts of the charge to the same temperature, in order to regulate the decomposition of the sulphates. During the last moments of this period of calcination, he takes small quantities of the matt from different parts of the furnace, and puts them in capsules, containing water, arranged in a line near the furnace. The decrease of the blue color imparted to the liquid in each capsule, shows the progress of the operation.

The assistant prepares a mixture of 15 kilogrammes of melted and pulverized salt, with 100 kilogrammes of cold roasted matt, and as soon as the assays indicate that the decomposition of the sulphates is sufficiently advanced, the prepared mixture is added. The workman charges it with a shovel, and mixes all the materials, as rapidly as possible endeavoring to produce an intimate mixture of the cold matt with that which is at a read heat upon the bottom of the furnace. He then closes the door, and allows the chloridizing to progress for a quarter of an hour, or twenty minutes at the most. He afterwards proceeds to withdraw the charge, and allows it to fall in a sheet-iron wheelbarrow, in which it is

left to cool until it can be wheeled away, and raised to the upper story of the store-house of roasted and chloridized matts.

The workman then throws down a new charge from the floor of the upper to the lower furnace, and the work continues; provided, always, that there are enough experienced workmen to properly conduct the operations during the night. In this case, nearly five charges can be worked in twenty-four hours, with a consumption of 1·20 to 1·25 tons of wood.

The wear of the furnace is slight; at least 300 days of action in each year are expected.

Expenses and Results of the Second Operation.—If we suppose that all the matts produced at Mansfeld (2,917 tons) are treated according to Augustin's method, and that each furnace can roast 337½ tons of matt, it would be necessary to have for roasting and chloridizing, nine double-soled reverberatory furnaces, and four furnaces for the preparation of the roasted matts which are to be mixed with the salt when cooled. These would consume 4,536 tons of wood, 193½ tons of salt, and employ workmen 15,120 days.

The details of cost of roasting and chloridizing are approximately as follows:

Wood	4,536 tons at	15 francs.	68,040	francs.
Salt	193.5 "	120 "	23,220	"
Labor	15,120 ds. "	3 "	45,360	"
Tools, repairs, and miscellaneus expenses			7,500	"
Total cost of chloridizing			144,120	francs.

Or by the ton of matt:

Wood	1.155 ton	23	fr.	325
Salt	0.066 "	7	"	920
Labor	5.2 days	15	"	600
Tools, repairs, and miscellaneous expenses		2	"	571
Cost per ton of matt		49	"	416.

In the condensing chambers, arranged above the furnaces, a large quantity of fine powder is collected; this is carried up during the work upon the upper sole, and is somewhat agglomerated by the volatilized chlorides.

These materials are only imperfectly oxydized and chloridized; nevertheless, they are taken to the lixiviation at the same time with the matts withdrawn from the lower furnaces.

I have not been able to procure any notes upon their quantity, and their percentage of chloride of silver.

Third Operation.—Lixiviation and Precipitation.—This series of operations requires but little explanation; the reactions are simple and easily understood; the work is neither laborious nor difficult, and may be easily regulated by the superintendent of the establishment, or the foreman of the precipitating room.

About 500 kilogrammes of the roasted and chloridized matts, while still hot, are placed in each of the dissolving tubs, which are arranged in line on an upper floor, or raised platform. A solution of common salt, containing from 20 to 22 per cent. of salt, and heated to 131° F. by the aid of steam, is then thrown in from a trough which extends above. When the tubs are nearly full, the supply is stopped, and the faucets at the bottom of the tubs are opened, so as to allow a part only of the liquid to run off. When the depth of the solution above the matts is reduced to $0^m.12$ to $0^m.15$, the faucets are closed, and the whole is left undisturbed for one hour. These first manipulations are intended to thoroughly impregnate the matts with the saline solution, and to dissolve out the greater part of the chlorides. The faucets are afterwards reopened, and all the liquid in the vats is allowed to run off. In order to complete the solution of the chloride of silver, and to wash the materials, a stream of solution of salt is allowed to run through the tubs for twenty hours without interruption; the faucets of discharge and supply being so adjusted that the matts are kept constantly covered to a very slight depth with the liquid.

In order to better distribute the solution throughout the mass, a disk of wood, pierced with small holes, is placed upon the surface of the matt. It is estimated that six cubic metres in volume of saline solution are required to flow through each tub, in order to dissolve and carry off the whole of the chloride of silver contained in the five hundred kilogrammes of matt. It may be ascertained that the washing is complete, by receiving a portion of the liquid which runs from the faucet in a capsule, and plunging into it a well-cleaned plate of copper; if there is no deposit of metal upon the surface, the washing may be regarded as complete. If, on the contrary, a film of silver is precipitated, the saline solution is allowed to run through the tub, until, by a new trial, it is found that a metallic precipitate is no longer formed upon the copper.

The liquid flowing from the faucets is conducted by troughs into two large vats, placed side by side above several series of tubs for precipitation. In each of the large vats the liquid enters by a wooden pipe or tube, which extends nearly to the bottom, while it runs off by a faucet placed near the top. This arrangement allows the fine matters carried through the filters of the dissolving tubs to be nearly all deposited. These accumulations are taken out at the end of each week when the work is stopped for the Sabbath.

The nearly clear solution is distributed by a trough between the different series of precipitating tubs. Each series is composed of four tubs, arranged one above the other. In the two upper tubs a thickness of about $0^{m}.15$ of cement-copper is placed in the compartments and upon the filters. The two lower tubs are filled nearly to the same height with small fragments of old iron. In each tub the liquid enters in the greater of the two compartments, passes through the filter, and rises in the smaller to flow out by the faucet placed nearly half way up.

The liquor thus passes through the metal twice, by which the precipitation should be completely effected. The flow is continued, and the saline liquor leaves the lower tubs completely deprived of silver and copper, but charged with a large portion of protochloride of iron.

Every two or three days, they stop the flow of the solution of chloride, successively, in each series of tubs, and take out the silver deposited upon the copper in the two upper tubs, and the copper precipitated by the iron in the two lower tubs. The supply of the two metals which serve for these precipitations is renewed, and the series is again put in action.

The waters which run off by the lower trough are conducted into two great basins, where the action of the oxygen of the air upon the protochloride of iron, causes the almost complete precipitation of the metal in the state of basic salt of the peroxyd. When this action appears to be ended, the saline solution is pumped up into a concentrating pan. In thus operating, the consumption of salt is much diminished, yet a considerable loss cannot be avoided, for the ferruginous deposits remain impregnated with a large proportion of the solution in which they were formed. They are too gelatinous to be easily washed, and besides, the washing would greatly increase the quantity of water to be evaporated in the concentrating pan.

The management of the dissolving tubs requires much manual labor. As soon as the washing is ended in a tub, it is rolled to the place of washing the cupriferous residues. It is filled with hot water, which has been used before, and is allowed to digest a few moments. The water is then drawn off by the faucet into a special reservoir. A second washing is made in the same way with warm water which has not been used; this, after being drawn off, serves for the first washing of the second tub, and can then be run off into the same reservoir. The operations are terminated by two washings with warm and cold water, but these last waters are not collected, as they contain too little salt.

The washing of the residues being terminated, the tub is turned over by the aid of a special apparatus, and the residues fall to the lower floor and accumulate, to be afterwards carried to the place where the black copper is smelted. The tub is replaced upon its wheels, and rolled under the dêpot of the roasted matts, where a new charge of five hundred kilogrammes is introduced; it is then wheeled back to its place under the conduit by which the saline solution is supplied. These tubs are also emptied and charged in succession in order that there may be no interruption in the precipitation.

Products and Reactions.—Three different useful products are obtained; the washed cupriferous residues, precipitated silver, and cement copper.

Residues.—The composition of the cupriferous residues varies with the purity of the matts submitted to the extraction. In the matts ordinarily obtained, there is but a small proportion of arsenic, and the residues are composed almost wholly of oxyds of iron and of copper; they contain but very little of the arseniates and of oxyds of cobalt, nickel, zinc, lead, &c. The percentage of silver may be disregarded when the operations have been well conducted, depending principally upon the care taken by the workmen in roasting and calcining.

In the treatment of highly arsenical matts, the residues are more impure, and always retain a little more silver. The chloridized matts contain in the state of arseniate of soda, the arsenic acid produced by the roasting. In the dissolving tubs the arseniate of soda and the soluble chlorides reproduce, by double decomposition, the metallic insoluble arseniates. A certain quantity of silver is found in the residues in the state

of insoluble arseniate; but this quantity is probably very small, and the per centage of silver in the residues certainly does not increase in proportion to the impurity of the matts. The residues, on the contrary, are as much more highly charged with arseniates as the matts contain more arsenic. The solution which runs into the precipitating tubs never contains arsenic.

The cupriferous residues should be washed very carefully with pure, warm water, in order to remove all the salt with which they are impregnated; this salt would be very injurious in smelting for black copper.

Unrefined Silver.—The precipitated silver forms a layer about 0 .05 in thickness above the cement in the two upper tubs of each series. It is taken out from these twice a week. It is quite impure, often containing a little copper and lead.

It is necessary to present some general remarks upon the precipitation of the silver, in order that the precautions necessary in taking out the precipitated metal, and the manipulation of the cement may be better understood.

The saline water containing the solution of the chloride of silver, and the other metallic chlorides, transverses in succession the four compartments of the two tubs which hold the cement copper.

The copper precipitates the silver rapidly, and a portion of lead slowly, and changes the perchlorides of iron and of copper into protochlorides; until this change is effected the precipitation of silver is not complete.

It will thus be seen how important it is to diminish, as much as possible, the proportion of the chlorides of iron and of copper, and, consequently, to push the calcination, which determines the decomposition of the sulphates of the two metals, as far as possible without risking the decomposition of any of the sulphate of silver. The presence of arsenic in the matt certainly has an influence upon the proportion of the chlorides of copper and iron in the chloridized matt; but a portion of these salts is decomposed by the arseniate of soda in the dissolving tubs, and does not pass into those for precipitation.

When the saline solution contains but little of the chlorides of iron and of copper, the silver is almost totally precipitated by the cement in the first compartment of the up-

per tub; only a small proportion is deposited in the three other compartments. This is usually the case at Mansfeld, but if the solution contains a considerable proportion of the two chlorides, the precipitation of the silver is less rapid, and a considerable part is deposited in the second tub. It is then necessary to increase the thickness of the cement in the four compartments, in order to ensure the complete precipitation of the silver. It is not necessary to consider more than the usual conditions; those where the larger portion of the silver is precipitated in the first compartment of the highest tub. When the surface of the copper is clean, the action upon the solution is very energetic, but is much less so when the layer of silver deposited upon it prevents the contact of the solution. It requires about three days for the whole of the copper to be replaced by the precipitated silver upon a thickness of $0^m.05$ to $0^m.06$. This layer may be taken out as unrefined silver, the copper being wholly replaced. The cement below, and in the three other compartments, is unchanged, or, at least, each grain of the copper is covered with but a slight thickness of silver.

It can only be known that the precipitation of the silver is complete, when the saline solution traverses a certain thickness of copper without depositing any silver; consequently, when it is perceived that any silver is deposited upon the copper in the last compartment, the cement copper in the second tub should be renewed.

The cement copper dissolved away cannot be utilized except in the first compartment of the upper tub, where the more energetic action of the saline liquor produces the rapid solution of the whole of the copper.

The cement copper of the lower tub is generally replaced at the end of each week, and is placed in the upper tub.

The manipulation is somewhat different when the saline solution contains a considerable proportion of chlorides of iron and copper. The copper of the first compartment then serves principally for the transformation of the perchlorides into protochlorides, and a third tub is necessary; or, if two only are used, the height, or thickness of the cement copper must be much increased in all the compartments. The precipitated silver is distributed in two or three of the compartments, and before removing it, it is necessary to see that all the copper is dissolved in one or the other.

The precipitated silver is refined and cast into ingots. The refining may be effected in black lead crucibles by a small proportion of nitre, or upon bone-dust cupels in a cupellation furnace. The first mode is the simplest, and answers very well when the silver does not contain much lead or copper. When the silver is very impure, and contains a considerable proportion of these metals cupellation is preferable, and this is the usual method at Mansfeld.

Cement Copper.—The copper precipitated by the scrap iron in the lower tubes is necessarily very impure, for the iron completely decomposes the chlorides of lead, and partially those of zinc, nickel, and cobalt. As the chemical action, favored by the arrangement adopted, is quite rapid, the air exercises very little action on the protochloride of iron, and the cement contains only a small proportion, not worthy of attention, of the basic salt of the peroxid of iron.

The cement is removed from the tubs very often, or as soon as it accumulates in a layer from 0 .09 to 0 .10 thick upon the surface of the iron. It is washed by decantation, for the purpose of removing the salt of the peroxyd of iron with the finer particles. These are received in a basin or reservoir, and are added to the oxydized residues in smelting for black copper. The washed cement is stored for use in precipitating the silver.

Expenses and Results of the Third Operation.—In order to treat, in one year of 300 working days, the 2917 tons of matts produced by the ores mined in 1850, twenty dissolving tubs and twenty-four precipitating tubs would be required. The different manipulations require ten workmen, under the direction of a suitable foreman. The saline solution used in one day would contain about 26 tons of salt, and the loss of salt may be estimated at one fifth, or less, of the quantity used, say 390 tons for the whole year. The heating of the boilers and pans would require about 600 tons of wood.

In 1850, 6,385.87 kilogrammes of silver were obtained and melted into ingots. The quantity of iron used is small and does not exceed eight tons.

According to these figures the expenses of this operation are as follows :

Labor and Superintendence,	Superintend. 300 days, at 4 francs,		1,200fr.
	Workmen, 3000 " " 2fr. 50c.		7,500 "
Wood,	600 tons " 15fr.		9,000 "
Salt,	390 " " 120fr.		46,800 "
Refining silver,			2,400 "
Iron, Tools, repairs and miscellaneous,			5,000 "
	Total cost,		71,900fr.

The ton of silver is 709 k., 485 of which the value at 222 francs the kilogramme is 157,505 francs 67c. The loss of copper is certainly considerable, but I have not the means of estimating it with accuracy. It is probable that it amounts to two and a half per cent. of the copper in the matts, or 34 tons upon the whole, of which the value is about 100,000 francs.

The costs per ton of matts are—

Labor and Superintendence,	1.131 day	2fr.	982
Wood,	0.205 ton	3fr.	075
Salt,	0.133 "	15fr.	960
Refining silver		0fr.	825
Iron, tools, repairs, and miscellaneous,		1fr.	730
Cost per ton of matts,		24fr.	572
Products: Silver in ingots,	2.189 kilogrammes,		
Copper in the residues,	0.450 ton.		
Metals lost, Silver,	0.243 k. value,	53fr.	946
Copper,	12.000 k. "	34fr.	275

In summing up the costs shown for each operation we obtain the following as the cost of extraction of the silver per ton of matts:

Wood	1.760 ton	26fr.	400
Salt	0.199 "	23fr.	880
Labor,	6.331 days,	18fr.	582
Stamping,		5fr.	000
Refining,		0fr.	825
Miscellaneous expenses,		4fr.	301
Total per ton,		78fr.	988

These costs are high, and the losses in silver and copper are great. It should be observed, however, that though the figures given have been calculated from practical working in the large way for a long time, yet they have not been sufficient to give the workmen that practical experience and skill which

is essential to the best results by this method. The difficulties attending the roasting and chloridizing have been dwelt upon, and certainly the consumption of salt, the losses of the metals and the loss of salt in the last part of the treatment, may be gradually diminished. For these reasons the preceding estimates and data may be regarded as a maximum for the costs and losses; they would not be reached in an establishment treating matts as pure as those of Mansfeld, regularly, by the Augustin method.

ZIERVOGEL'S PROCESS.

The second process of extraction of silver, the invention of Mr. Ziervogel, is more simple than the preceding, and less expensive, but is more difficult of application. It differs from the method described by a very important simplification. Mr. Augustin regards it as indispensable to change the silver into chloride, in order to dissolve it easily in a solution of chloride, of sodium. Mr. Ziervogel does not admit the necessity of this change, but thinks it possible to dissolve, by warm water alone, the whole of the silver, which exists as sulphate after the roasting. The following is the series of operations:

1. Stamping and grinding the argentiferous matts. 2. Roasting and calcination. 3. Lixiviation and precipitation.

As these operations are very similar to those corresponding to Augustin's method, but few additional details are necessary.

First Operation.—The matts are stamped, and then ground to powder in a mill. The granules of metallic copper, which are found in small quantity, are separated by washing, and taken to the smelter for black copper; the silver which they contain is lost.

Second Operation—Roasting and Calcination.—The end proposed to be obtained is to transform the whole of the silver into sulphate soluble in water, and to leave as small a proportion as possible of the soluble sulphates of the other metals. This last condition is very different from that described in Augustin's method; in fact, by this method the sulphates are all transformed into chlorides, and in the following operation the presence of the perchlorides of iron and copper greatly interferes with the precipitation of the silver by the copper. In Ziervogel's process the sulphates existing in the roasted matts are dissolved out by hot water. The

sulphates of iron and of copper in a neutral solution do not have as great an influence upon the precipitation of silver as the chlorides of the same metals in a saline liquor. The basic sulphates of iron and copper, insoluble in water, cannot obstruct the subsequent operations, they are even very useful in the treatment of the cupriferous residues, by reason of the little sulphur they contain.

The operation is conducted in a reverberatory furnace, with two soles superimposed, like that previously described. It is divided into two parts, roasting and calcination. Upon the upper sole the matt is submitted to the action of air in excess, at a low temperature, not exceeding a dull redness. They endeavor to thoroughly oxydize the materials of the matt, and to produce such a large proportion of metallic sulphates that they can be certain of the complete sulphatization of the silver. Upon the lower sole, the roasted matt is gradually raised to a cherry-red heat; it is necessary to decompose the greater part of the sulphates, except the sulphate of silver, no portion of which should be destroyed, nor its solubility in water diminished by prolonged calcination. This is the great difficulty of the roasting in Ziervogel's process. It is not only necessary to carry the whole of the silver to the state of sulphate, but to preserve the solubility of this sulphate, always feeble, in obtaining as much as possible of the other metals in the state of oxyds and insoluble basic sulphates.

With experienced and well-directed workmen, the result may be obtained when the matts do not contain a notable proportion of arsenic and antimony; but in operating upon matts containing a certain quantity of these two substances it is impossible to avoid the formation of arseniate and of antimoniate of silver; the proportion of these depending upon the proportion of arsenic and antimony present. They have not, as in the roasting of non-argentiferous matts in Wales, the faculty of volatilizing the larger part of these two bodies in the first period of the operation, and the arseniates and the antimoniates are not decomposed during the calcination. It appears to me important to dwell a little upon these difficulties. In roasting at a low temperature the action of the air in excess facilitates the production of the sulphates, but at the same time, causes nearly all of the arsenic and the antimony to pass into the state of arseniates and antimoniates; it is not possible to produce arsenious acid and the oxyd of antimony, both

volatile, without greatly limiting the proportion of oxygen required for the roasting. By this a large proportion of sulphur would necessarily be lost in the state of sulphurous acid, and there would be no certainty of producing sufficient sulphuric acid for sulphatizing the whole of the silver. In treating the impure matts they are thus placed between two difficulties. In seeking to expel as much as possible of the arsenic and antimony by limiting the access of the air required for the oxydation they lose much of the sulphur, and are liable to leave a large part of the silver in the metallic state; in giving an excess of air, the change of the silver into sulphate is more certain, but only an insignificant portion of arsenic and antimony is expelled, and a part of the silver is rendered insoluble by the formation of arseniate and antimoniate.

For some years past the attempt has been made to resolve this problem by an ingenious plan. Free access of air is allowed in the furnace, but they mix with the matt on the upper sole, ten per cent. of lignite in small fragments. The gases and watery vapor slowly given off from this combustible, during the first part of the roasting process, prevent the free action of the oxygen, and a large quantity of arsenic and antimony is volatilized in the state of arsenious acid and oxyd of antimony. Sulphur is lost, and more, probably, than there would be in roasting the matt alone with a limited access of air, for the lignite causes the formation of much sulphuretted hydrogen. The sulphatization of the silver is chiefly produced on the lower sole of the furnace by the sulphurous and sulphuric acids disengaged in calcination.

The extraction of silver is now conducted upon matts richer in copper than those treated 1850. They are concentrated to 65 or 66 per cent. by roasting in a reverberatory, in which a certain quantity of arsenic is expelled with a necessary loss of sulphur. As these changes are subsequent to the year for which the numerical results are given, they are merely noticed; the following descriptions and observations are based upon the operations as conducted in 1850.

Method of Operation.—The upper sole of the furnace is charged with 216 kilogrammes of pulverized matts, and the roasting is conducted as in Augustin's method. The heat is kept below a dull redness until towards the end of this first period of oxydation, the charge is then thrown down into the

lower furnace, and is heated gradually to a cherry-redness. This heat is kept up for an hour, or more, or as long as white vapors are given off freely. The calcination is regarded as complete, when trials made as in Augustin's method, give only a very slight blue color to the water. When this point is reached the charge is withdrawn ; the furnace is allowed to cool a little by leaving the door open for a few minutes ; a fresh charge is thrown down upon the upper sole, and the operation proceeds as before. Usually the matt remains four hours upon each of the two soles, and five or six charges may be worked in twenty-four hours.

Expenses and Results of the Second Operation.—The roasting of the 2,917 tons of matts produced by the ores mined in 1850 requires nine double-soled furnaces attended by 36 special workmen; the movements of the combustibles and of the matts being effected by common laborers. The consumption of wood for the whole year is 3,200 tons. The costs of roasting are as follows :

Wood 3,200 at 15 fr.	48,000 fr.
Labor 10,800 days at 2 fr. 50c.	27,000 fr.
Transportation, tools, repairs and miscellaneous.	7,000 fr.
Total cost of roasting	82,000 francs.

Roasting gives but one principal product—the matt withdrawn from the lower furnace, which is taken in sheet-iron wheelbarrows to the storehouse for lixiviation. A second product is taken from the condensing chamber above, where the fine dust of the charge and a part of the fumes carried up by the draught are deposited. The quantity of these materials is small, and as the oxydation is incomplete they should be returned to the furnace for roasting.

In the matts ready for lixiviation the greater portion of the zinc, nickel, cobalt, and silver, and a small proportion of the iron and copper, are in the state of sulphates. Nearly all the iron and copper, and a small part of the nickel, cobalt, and zinc are in the state of oxyds or insoluble sulphates. A small part of the silver remains in the metallic state, when the roasting and calcination has not been properly conducted. When the matts contain arsenic and antimony the roasted product contains a considerable portion of arseniates and antimoniates of all the metals. It is impossible to know to what extent these insoluble compounds of silver are formed.

Third Operation—Lixiviation and Precipitation.—The arrangement of the apparatus and the conduct of the operations are nearly the same as in Augustin's method. The tubs for dissolving and precipitation are arranged in the same way. In each of the dissolving tubs 216 kilogrammes of roasted matt are placed, and, if possible, while its temperature is yet high—greater than that of the water employed. The tubs are then filled with water, heated to about 149° F.; a portion is allowed to run off and the remainder is left undisturbed for an hour; the level of the water being about 0.15 above the materials. The lower faucet is afterwards opened and a continuous stream of hot water is allowed to flow over the matts for sixteen or eighteen hours. After this time a trial of the water coming from the tub is made with a clean plate of copper, and if no trace of silver is deposited on it, the solution and washing may be considered as complete. The tub is then emptied, refilled and returned to its place. We may allow that each tub is emptied and charged once in twenty-four hours, and that four or five cubic metres of hot water are required for the complete solution of the sulphate of silver.

The conduct of the following operations—the precipitation of the silver by copper, and the copper by the iron,—is so nearly identical with that in Augustin's method that no further description is required.

There is no necessity for a basin or reservoir to receive the waters after the precipitation of the copper by the iron, or for washing the residues of the lixiviation.

A few observations upon the chemical actions of these portions of the process may now be made.

In dissolving out the sulphate of silver, the matt is first saturated with water as completely as possible, and allowed to digest for some time without opening the lower faucet. By this only a small part of the sulphate of silver is dissolved, inasmuch as this salt, formed in the dry way, is sparingly soluble. This first digestion serves then only to prepare for the solution, which is gradually effected during the whole time of the operation. That they succeed in dissolving the whole of the sulphate of silver is by no means certain, for the trials made by plates of copper towards the end of the time are not sufficiently sensitive. The residues of the lixiviation are always notably argentiferous, and it must be admitted that

more or less of this silver is in the state of sulphate that might have been dissolved out by prolonging the washing with hot water. The solution of the sulphate is, besides, always retarded when the matts have been heated too much or too long, and, consequently, the time during which the hot water is used should be varied according to the conduct of the roasting and calcination. It happens, from time to time, that the washed residues emptied from the tubs still contain enough silver, as sulphate, to justify lixiviating a second time. Such residues are assayed for silver, without regard to its solubility or insolubility in water, and if the proportion present is found to exceed 25 grammes in 100 kilogrammes the residues are roasted over again, being first dried and then mixed with the unroasted matt. It would appear at first view to be more economical to re-wash such residues and not to send back to the furnace materials already containing a large part of the silver in the state of sulphate. It is, however, easy to show that the method adopted is the most simple. The richness of these residues in silver is owing to the neglect of the workmen during the process of roasting,* either the calcination has been carried too far, thus decomposing a part of the sulphate of silver, or, at least, diminishing its solubility. These workmen therefore are very properly under obligations to repeat the roasting of such rich residues without remuneration.

Apart from this established regulation, the roasting of the residues mixed with the matts is the best method that can be had to again form the soluble sulphate of silver, either from metallic silver, or from the sulphate, which has been overheated in the calcination.

When matts containing arsenic and antimony have been treated, the residues may be rich in silver without any fault on the part of the workmen and a new roasting would decompose only a very small part of the arseniate and the antimoniate of silver. Further, the proportions of arsenic and antimony in the matt, and consequently, those of the arseniates and antimoniates contained in the product of the roasting, are rather variable. The percentage of silver of the residues of the lixiviation is no longer any indication of the care bestowed by the workmen in roasting, and it cannot be

* Those matts only which are nearly free from arsenic and antimony are here spoken of.

known what residues it would be best to submit to a second roasting. The loss in silver is necessarily rather large, and the success of the operation depends in great part upon the experience and attention of the overseer of the department.

For the matts at Mansfeld, which may be considered as very pure, the limit of twenty-five grammes of silver to 100 kilogrammes of residues has been adopted as the result of long experience, and it is certainly greater than the portion of silver which might exist in the state of arseniate and antimoniate.

The waters which flow from the dissolving tubs contain sulphates of zinc, cobalt, nickel, copper, iron, silver, and lead. The proportion of the three first depends almost wholly upon the composition of the matt, for they cannot be decomposed in the calcination which ends the roasting, without risking the destruction at the same time of a part of the silver salt. They are, however, without any bad influence in the subsequent precipitations. The quantity of the sulphates of iron and of copper varies with the temperature and the duration of the calcination; these salts are always in larger proportion than the chlorides of the same metals in the saline solution of Augustin's method; for the calcination should not be much extended for fear of destroying the solubility of the sulphate of silver. The sulphate of lead, on the contrary, can exist only in small quantities, for it is but slightly soluble after prolonged calcination.

Precipitation.—In the upper tubs containing the cement, the copper acts slowly upon the sulphates of iron and of copper, rapidly upon the salt of silver, partially upon that of lead. It is without notable action upon the salts of zinc, nickel, and cobalt. The precipitation of the silver proceeds with as much facility as in Augustin's method, although the solution contains a considerable proportion of salts of copper and of iron. The sulphates of these metals do not retard the action of the copper upon the sulphates of silver as strongly as the chlorides in a saline liquor.

The precipitated silver is very pure, and can contain only a trace of lead, since the solution of the sulphates contains very little of this metal, and the copper decomposes only a part of the sulphate of lead. It is not customary to melt the silver in black lead crucibles; it is refined on a cupel. This refining is, however, not required if suitable precautions are taken when

the silver is removed from the surface of the cement. The copper is rapidly covered with a crust of silver, which completely envelopes the grains. The metal enclosed in this silver deposit dissolves very slowly ; care must be taken not to remove the precipitate, formed in the first tub of each series, below the level at which experience indicates the complete disappearance of the copper.

The precipitated silver contains sulphate of lime in admixture, when the water used in lixiviating, contains this salt. By being repeatedly used and becoming gradually concentrated, by evaporation, the sulphate of lime is finally deposited in the first tubs.

It is not necessary to dwell upon the precipitation of the copper by the iron. The precipitate is divided into two portions by successive decantations ; the heaviest grains are nearly pure copper, and are used for precipitating the silver. The finer portions contain a certain quantity of salt of peroxyd of iron, a little zinc, cobalt, nickel, and lead, and are re-smelted with the cupriferous residues.

Expenses and Products of the Third Operation.—To treat 2917 tons of roasted matts there must be two departments for lixiviation, each containing 24 dissolving tubs, and 24 precipitating tubs. The boilers and heaters require 600 tons of wood a year. The work can easily be done by six workmen under the direction of one superintendent.

The loss of silver is about eight per cent., or 567k. 59. They obtain 6,527k. 267 in ingots. These numbers are calculated from the results of working very pure matts obtained from ordinary ores. In matts less free from arsenic and antimony the loss of silver is probably near ten per cent.

The total cost of extracting the silver from this quantity of the prepared matts is 22,100 francs, or, per ton of matts, as follows :

Wood	0.205 tons	3 fr. 075
Labor	0.720 days	1 " 954
Refining Silver		0 " 825
Iron, Tools, repairs, miscellaneous		1 " 730
	Total cost per ton of matt	7 " 584

Yield of one ton in ingot of silver	2.237 Kilogrammes.
Loss in silver	0.195 "
Value of silver lost	43 fr. 29c.

Taking the sum of the costs for the three series of operations, the cost of the extraction of silver by Ziervogel's method is obtained and is, per ton of matt, as follows:

Stamping and Grinding	5 fr. 000
Refining Silver and casting into ingots	0 " 825
Wood, 1.301 tons	19 " 515
Labor and Superintendence, 4.42 days	11 " 204
Miscellaneous expenses	4 " 470
Cost of extraction per ton	41 fr. 014

The loss in silver is 0.195 kilogrammes; that of copper may be disregarded. The cost of extraction per ton of ores may be calculated as follows:

Stamping and pulverising	0 fr. 445
Refining Silver	0 " 073
Wood, 1.116 tons	1 " 740
Labor, 0.393 days	0 " 997
Miscellaneous	0 " 398
Cost of extraction per ton of ore	3 fr. 653
Loss of Silver 0.0174 kilogrammes—value,	3 fr. 865

We may allow that there are 2900 tons of cupriferous residues containing 1347 tons of copper, or, 0,041 tons of copper to the ton of ores. The whole amount of silver extracted being 6527k. 267, the yield, per ton of ores, is 0.1916 kilogrammes.

GENERAL OBSERVATIONS UPON THE TWO METHODS OF EXTRACTION.

The figures which have been presented upon the costs of extraction must only be regarded as approximations, but they are sufficient to prove that the process of Ziervogel is less costly and more economical than Augustin's. It has also the advantage of avoiding any great loss of copper, and of giving residues containing a certain portion of basic sulphates, the sulphur of which is useful in the smelting of these residues for black copper.

In regard to the loss in silver, it must be admitted that, when matts, which are tolerably pure, are treated by Ziervogel's method, it is less than in Augustin's method. In this respect, however, the inferiority of the latter has not been

fully shown ; for this method permits of the extraction of a larger proportion of silver from matts which are somewhat charged with arsenic.

A brief *résumé* will now be given of the difficulties in the application, and of the causes of loss of metals in each of the two methods.

In Augustin's method, the essential point is the production of the chloride in the dry way. When the whole of the silver is changed to chloride, and the greater portion of all the other metals is left in the state of oxyds, the operation is a successful one, and there is no fear of losing any considerable portion of silver in the following operations. The chloride is easily soluble in a warm liquid containing 22 per cent. of salt, and the lixiviation and precipitation only require care on the part of the workmen, and the attention of an intelligent superintendent.

The difficulties of chloridizing in the dry way, are very great, not only in the operation itself, but principally in the preceding operations of roasting and calcining. In changing all the silver present into sulphate by calcination, at a low temperature in the presence of an excess of air, sulphates of all the other metals are formed. These may be almost completely decomposed by a prolonged calcination, but it is not possible to raise the temperature high enough to attain the desired result without decomposing the sulphate of silver. The sulphates of iron and copper may be almost wholly decomposed; but those of lead, zinc, cobalt, and nickel, remain almost unchanged. The success of the *calcination* thus depends, in part, upon the care taken by the workmen, but chiefly upon the chemical composition of the matt submitted to treatment.

The transformation of the sulphates into chlorides should be rapidly made, at a low temperature, as the chloride of silver and the chlorides of the other metals are volatile. The chlorides of iron and of zinc are the most volatile, and produce the greater part of the loss in silver. By carefully conducting the roasting and calcination, the quantity of chloride of iron may be much diminished, but it is not so with the chloride of zinc. It is therefore essential to avoid submitting matts containing zinc to the process. Only a portion of the volatilized chlorides is collected in the condensing-chambers above.

With matts containing arsenic and antimony, the difficulties are much greater. Roasting at a low temperature with an excess of air, changes nearly all the arsenic and antimony into arseniates and antimoniates which cannot be decomposed

by calcination, and must be changed into chlorides. A longer continued and greater heat is required in chloridizing; and the formation of a large quantity of chloride of iron cannot be avoided. The loss of silver by volatilization of the chlorides, is much greater than with the pure matts.

In Ziervogel's method, applied to very pure matts, the chief difficulty is to so modify the temperature during calcination, as not to destroy the solubility of the sulphate of silver in water. For this part of the elaboration of the matts, the method is much superior to Augustin's, since it avoids the difficulties and the causes of loss in chloridizing.

The solution of the sulphate of silver in water is always very slow and difficult, and it cannot be known when it is complete. It is necessary to assay the residues for silver, and to roast over again those that are too rich. This richness of the residues in silver entails a loss which is nearly equivalent to the loss by volatilization of the chlorides in Augustin's method. There cannot be a great difference between the proportion of silver taken from the matts by the two methods, and it can only be presumed, if the operations by each are conducted with all the necessary precautions, that the loss of silver is a little the least by Ziervogel's. The expenses, also, being less, this method is, without doubt, the most advantageous for very pure matts.

When the matts contain a notable proportion of arsenic and antimony, there is always a certain quantity of arseniate and antimoniate of silver formed, which are insoluble in water, even when recourse is had to mixing lignite with the charges, or to the action of steam thrown in upon the sole of the furnace, as at Freiberg.

All the silver so combined is necessarily lost; while in Augustin's method, a portion of the chloride of silver formed from the decomposition of the arseniate and antimoniate during roasting, may be expected to remain in that state during the process of lixiviation.

It cannot, therefore, be said that with matts containing arsenic and antimony, Ziervogel's method yields more silver than Augustin's.

Sufficient comparative experiments upon this subject have not yet been made, and from those that have, it cannot yet be decided which of the two methods is the most advantageous for extracting the silver from the impure matts. It

is only well demonstrated that the loss in silver is, in all cases,* greatly increased by the presence of arsenic and antimony.

The cupriferous residues are nearly equally charged with arsenic and antimony, but those left by Ziervogel's process contain basic sulphates which are very useful in smelting for black copper. By Augustin's method, there is always a notable loss of copper, and the residues are without sulphur.

ART. II.—RE-EXAMINATION OF THE TETRADYMITE (BORNITE JACKSON.) FROM FIELD'S GOLD MINE, GEORGIA; AND ON A NEW MODIFICATION OF WOLFRAM. BY DR. F. A. GENTH, Consulting Geologist and Chemist.

The announcement by Dr. C. T. Jackson, of Boston, (Sill. Am. Journ., 2d ser. xxvii, 336. Mining Magazine, 2d Ser. I. 83), that the Tetradymite from Field's Gold Mine near Dahlonega, Georgia, has the composition of the Brazilian mineral Bornite, has taken many of our mineralogists by surprise. But as the methods, adopted by Dr. Jackson, cannot give correct results, I considered a re-examination of this mineral desirable.

Dr. Jackson states that he separated the bismuth from the nitric acid solution by carbonate of ammonia, and by a repeated treatment in the same manner, he frees it from all traces of "*telluric*" acid. The selenium he converts by aqua regia into "*selenic*" acid and afterwards separates by chloride of barium.

I have, for the separation of Tellurium from Bismuth, made use of two different methods. In the first analysis I have separated these two metals by treating their sulphides with polysulphide of ammonium. A repetition of the same method proved that the separation had been complete. In the second one the tellurium was separated from a solution of both metals, containing a considerable excess of free sulphuric and chlorhydric acids, by sulphurous acid. The tellurium, after standing on a warm place for more than three days, was filtered on a tared filter, washed first with a mixture of hot chlorhydric and sulphurous acids, then with sulphurous acid alone, and finally with pure water. This method, though frequently giving too much tellurium, will not do so, if the above precautions are kept in mind.

Particular attention was paid to the exact separation of

* Ziervogel's process is now preferred at Mansfeld.—*Translator.*

selenium from tellurium, but only an unweighable trace of it was found in nearly three grammes of the mineral.

The following are the results of my analysis:

	I.	II.	III.	Dr. Jackson found:
	Sp. grav. at 18°C=7.941.		Theory	
Bismuth,	50.83*	50.97	52.0	79.08
Tellurium,	48.22	47.25	48.0	18.00
Copper,	0.06	0.06		
Iron,	0.17	0.25		
Gold quartz, &c.,	0.72	0.80		0.60
Selenium,	——	0.67		1.14
Loss,	*trace.*	*trace.*		1.18

From my analysis it appears that the Tetradymite from Field's Gold Mine is not *Bornite*, but has exactly the same composition as that from the Tellurium Mine, Fluvanna County, Va., analyzed by me about 6 years ago (Sill. Am. Journ. 2d ser. xix, 16), with which it also agrees in all its physical properties.

PHILADELPHIA, 16th January, 1860.

A NEW MODIFICATION OF WOLFRAM.—The observation that an alloy of tungsten and steel possesses very valuable properties, such as extraordinary hardness and tenacity at the same time, and the fact that it has been already prepared on a large scale in Austria, and introduced into market, where it has invariably given great satisfaction, renders the discovery of large quantities of Wolfram or Scheelite, ores from which this alloy can be prepared, a matter of great importance. The localities of these minerals in this country, and especially those in North Carolina, contain them in too small quantities, and at the same time so much mixed up with pyrites, chalcopyrite, gold ores, etc., that large masses cannot be obtained from there. I was, therefore, much pleased, a short time go, to receive, through the kindness of my friend, Louis Beckers, Esq., wolfram, from a new locality, St. Francis county, Missouri, 1½ miles from St. Francis' River. It is associated with quartz and a little mica, from which it can be easily separated by its higher specific gravity. It is said to occur in considerable quantities.

It is found in indistinct crystalline masses, implanted in quartz, with very distinct cleavage parallel to the brachydiagonal. The color is brownish-black, the lustre submetallic,

* From the loss; the exact quantity found was 52.54, but it was, on examining its purity, found to contain a little carbonic acid.

and the streak cinnamon-brown. The specific gravity was found to be 6.670.

Mr. George J. Pöpplein made a chemical examination in my laboratory, and found its composition to be:

	I. By fusion with carbonate of soda.	II. By decomposition with chlorhydric acid.
Tungstic acid,	75.29	75.52
Oxyd of iron,	5.69	not determined.
Oxyd of manganese,	19.02	19.73
Lime,	1.13	not determined.

From these analyses it will be seen that this variety of wolfram differs from all others by its higher per centage of manganese. The oxygen ratio of the constituents is as follows:

$$WO_3 : FeO : MnO : CaO = 15.56 : 1.26 : 4.28 : 0.32.$$

This composition shows that the St. Francis County, Mo., wolfram forms a new and very interesting type of this mineral corresponding with the formula:

$$FeO.WO_3 + 4\ MnO.WO_3$$

PHILADELPHIA, 8th February, 1860.

ART. III.—EXTRACT FROM A REPORT OF DR. CHARLES T. JACKSON UPON THE YAHOOLA GOLD PLACERS.*

To T. C. A. Dexter, Esq., Treasurer, Yahoola River and Cane Creek Hydraulic Mining Company.

IN accordance with your request and instructions, I left Boston on the 8th instant, and repaired to Dahlonega, Lumpkin County, Georgia, and made a full and minute examination of the Gold Region, reported upon by Mr. Wm. P. Blake in October last.

Having, on two previous explorations of this gold region,

* Extracted from "*Gold Placers in the vicinity of Dahlonega, Georgia.*" 8vo. Boston. 1859.

in 1853 and 1854, made myself pretty well acquainted with the various placers or deposits of gold, and with the principal auriferous veins in that district, much of my present work consisted in a review of localities which I had previously explored, though some additional researches were made, and to a much greater extent, during my present survey.

I found that all the veins which are represented on Mr. Blake's map of the gold belt, really exist, and to the full extent described, and that they are all correctly reported, as to productiveness.

By testing with the pan, the soil and the rocks of these veins, gold was always obtained, in proportions that would pay in large operations.

The gold is found in both the slate rock and in the thin quartz veins, which alternate with the strata; also in the soil arising from the decomposition and disintegration of the slate rocks.

It is certain, that in the immediate vicinity of the veins the gold is most abundant, and that in the placers they enrich as we descend to the bed rock; but still I found it quite impossible to find any of the soil entirely free from gold, and it is my belief that not a square rod of land in the gold belt can be found that will not give a show of gold, in a pan of earth, of three or four quarts' measure.

I had some hundreds of panfuls of the soil, from all parts of the district, and from various depths, washed by experienced hands, under my immediate direction, and found gold in every pan. Gold is therefore found generally diffused in the soil, but it is more abundant near auriferous veins, and near the bed rock, in the different mines or placers.

I examined with care, level in hand, the elevations of the different ridges and ravines, with a view to the determination of the practicability of washing for gold by means of the Yahoola ditch about to be constructed, and I find that a long and narrow ridge, called the "*back bone*," which extends from lot 793 (the Georgia Gold Co.'s lot) to near the Finley veins, on lot 1,048, carrying the Golihau and Britton's veins, is too high to be reached by the waters of the ditch, but the ravines on the branches of the numerous tributaries of the Chestatee and the Yahoola rivers, are reached by the water, as are all the deposit mines along the course of these rivers and their branches, and also those of Cane Creek. So also I find that

and the streak cinnamon-brown. The specific gravity was found to be 6.670.

Mr. George J. Pöpplein made a chemical examination in my laboratory, and found its composition to be:

	I. By fusion with carbonate of soda.	II. By decomposition with chlorhydric acid.
Tungstic acid, ...	75.29	75.52
Oxyd of iron, ...	5.69	not determined
Oxyd of manganese, . .	19.02	19.73
Lime, ...	1.13	not determined

From these analyses it will be seen that this variety of wolfram differs from all others by its higher per centage of manganese. The oxygen ratio of the constituents is as follows:

$$WO_3 : FeO : MnO : CaO = 15.56 : 1.26 : 4.28 : 0.3$$

This composition shows that the St. Francis County, Mo., wolfram forms a new and very interesting type of this mineral corresponding with the formula:

$$FeO.WO_3 + 4\ MnO.WO_3$$

PHILADELPHIA, 8th February, 1860.

ART. III.—EXTRACT FROM A REPORT OF DR. CHARL[illegible] JACKSON UPON THE YAHOOLA GOLD PLACERS.*

To T. C. A. Dexter, Esq., Treasurer, Yahoola Ri[illegible] Hydraulic Minin[illegible]

IN acco[illegible]

[illegible] gold

[illegible] *hlonega,*

d
k.
of
its
re
an
es
he
the
re-
ins.
gold
ned,
over
nally

disin-
always
e mag-
all the

It was
hloride of
c oxyds of
chloride of
ride of iron
heory is sus-
gold mines of
us veins, where
with the mate-

the upper portion of Pigeon Roost streak, a very rich gold mine, cannot be reached by the waters of either the Chestatee or Yahoola ditches. The lower deposits, on the sides of the hills and on the numerous branches, may all be reached with a sufficient head of water, for washing out the gold. The land, not reached by the water, may be estimated at three miles in length, by from one-quarter to half a mile in width. All the rest of the belt is fully commanded by a head of water, adequate to the purpose of gold washing.

I find on consulting with Mr. Singleton, the engineer, who has levelled the whole route of the water works, that the head of the water at Dahlonega hill, will be 275 feet above the level of the river at that point. This is vastly more head than is needed for the lower ravines and branches; hence the water may in its descent be employed to drive the wheels of a mill, near the village of Dahlonega, and still the water will have abundant head for the washing operations.

I found on inquiry of numerous respectable persons familiar with the Yahoola River, that there is little danger to be apprehended of a want of water in that river in the driest seasons; the river receiving its supplies from mountain springs chiefly. At the time of my visit, the rivers were all very high, so that I could not gauge the waters to any advantage, there being at this time almost a *freshet.*

There can be no doubt as to the practicability of the enterprise of bringing the waters of the Yahoola River to Dahlonega, for gold washing.

About one-fifth of the ditch is now made, and hands can be put on to complete the work very soon. The high trestle aqueduct is the chief difficulty to overcome. This will be 240 feet high at its highest point, and 1,000 feet in length. This work, of course, should be made strong, so as to last for many years without essential repairs.

I understand the whole work is to be taken on contract, and that it will be executed accordingly. The ditch is let out in small portions, so that there is no danger of failure of the parties to complete the work, even though it might not prove profitable to them.

I find the deposit mines are all admirably situated for the ready removal of the tailings, or earth washings, from the water-works. I know of no situations that can be compared with these in this country for the above-named purposes. The descent of the branches of all these streams is very rapid.

It is the general opinion of the people of Dahlonega, who are competent to form a reliable opinion, that the hydraulic works of the Yahoola will be successful. Several returned Californians, competent to judge, from their previous experience in such matters, are decidedly convinced of the value of this new enterprise, and look upon it as a matter of certainty that it will prove successful and highly profitable.

The Georgia Gold Company's property is commanded by the waters of this ditch, but may also be worked by a ditch from the upper waters of Cane Creek, so that they can choose between these waters.

I learned that the Georgia Gold Company are about to recommence their mining operations, which had been suspended for some time on account of financial difficulties in New York. This company will have to adopt the hydraulic system of working at their mines, and I have no doubt that large profits will be obtained, for the auriferous rocks at this location are decomposed and disintegrated to the depth of more than eighty feet, the soil so formed being very light, and like ashes when dry. It will wash away with great ease and leave the gold behind. The thin quartz layers are rich in gold, and the rocks near them are also charged with gold, so that rich returns may be obtained by washing out these thin quartz veins.

It is said that the general average of the soil at this gold mine yields three cents per bushel, value of the gold obtained, but near the quartz veins the decomposed rock will average over ten cents per bushel, and some rich pockets are occasionally found from which much gold is obtained.

Gold is found both diffused in the soil formed from disintegrated rocks and in the rocks themselves. It is always associated with specular iron ore, Ilmenite, and a little magnetic iron ore, these constituting the black sands of all the gold mines.

I have no doubt as to the origin of the gold. It was raised as a metallic emanation, with the vapor of chloride of iron, the latter changing into specular and magnetic oxyds of iron, by the agency of water and heat; while the chloride of gold, mechanically brought up by the heavy chloride of iron vapor, was deposited in its metallic state. This theory is sustained by all the phenomena presented in the gold mines of the country, with the exception of the pyritiferous veins, where the gold probably was raised in combination with the mate-

rials that formed the pyrites. Copper and iron pyrites are very rarely found in the gold-belt of Dahlonega, but specular and magnetic iron ores are very abundant, from half an ounce to an ounce of it often being obtained with the gold, per pan of three or four quarts' measure.

The origin of specular and magnetic iron ores is well known, both from observations made in the craters of Vesuvius, Stromboli, and Etna, where they are seen to arise from sublimed and decomposed chloride of iron ; and from laboratory experiments, by which they are easily made.

The original observations and experimental researches, on the formation of specular iron ore by sublimation, were made by Gay Lussac. The application of the same theory, to explain the origin of native gold, silver, and copper, in certain localities, is my own.

With regard to the practicability of the hydraulic method of working these gold placers, and many of the decomposed rocks for gold, I have not the slightest doubt of its being the best method of operating, and in this view all persons in Dahlonega, competent to give a reliable opinion, as before observed, coincide with me.

The want of water on the mining grounds is all that has stood in the way of profitable workings heretofore. It was obvious, on seeing the great activity of the gold washers of Dahlonega, subsequent to the late heavy rains, which furnished a temporary supply of water, and from their general success in obtaining profitable returns while working only with a "*tom*," that the application of water by the hose will certainly give profitable returns in gold. Many old deposits that have been washed over several times before, give still from fifty to seventy-five cents per day per hand, as the lowest yield, while in some placers not before washed, the yield per hand per day was from $5 to $10. I saw in one place, 21 dwts. of gold obtained from ninety bushels of soil, taken off from the bed-rock by Mr. Asbury, near Town Creek ; and he informed me that two days before he obtained 44 dwts. from the same measure of soil. This was worked by four men—one to dig and load the earth into the cart, one to drive the team, and two to wash the earth in a "tom," a washing trough, having a sieve-like perforated iron-plate at the lower end, and a riffle-box underneath it to collect the gold. No mercury was employed, and only the coarse gold was saved.

I called upon the Recorder of Deeds at Dahlonega, and inquired of him if Drs. Van Dyke & Hamilton had recorded at his office full leases of the water of the Yahoola River, and of their lands for gold-washing, on payment of 10 per cent. royalty on the gold obtained, and was assured that such was the case, and that the records were all made, and that the whole extent of water and land required was secured by legal grants.

I rode over the principal lines of section of the proposed canal or ditch, and saw what was already done, and observed the level of all points where the canal and trestle were to be established, and noted the places which would not be commanded by the water in sufficient power for gold-washing by the hydraulic method.

I am fully satisfied that more land is commanded by these waters than can be washed in half a century, and that the numerous dry ravines and small branches of streamlets will prove very productive in gold.

As to the cost of the water-works, it seemed to me to be so very low, that I could not believe it possible that they could be completed for $50,000. I therefore called for a copy of the estimate, which was given me by Dr. Hamilton, and is annexed to this report.

To my objection that the contractors might fail, the reply was, that no one person had so large a contract, as to render it probable that any failure would take place. Labor is very cheap and abundant at Dahlonega, and white men take the contracts with great readiness. No negroes were employed on these works while I was at Dahlonega.

Estimate of the Cost of the Yahoola Works, by contract.

$13\frac{3}{4}$ miles of ditch, @ $3 20 per mile, - - -	$3,800
25,000 cubic yards of cuts, @ 10 cents per yard, - -	2,500
150,000 feet hard lumber delivered at the different small tressels, @ $3 50 per hundred, - - - - -	4,250
2,000 feet hard lumber for the big trestle, delivered, @ $4, -	8,000
180,000 sawed lumber for flumes, and delivered, @ $3, - -	5,400
8,000 feet plank house, @ 50 cents per foot, - -	4,000
200 kegs of nails, delivered, - - - -	1,000
1,000 feet of leather hose, - - - -	1,700
50 " " - - - -	450
Wages of Superintendent, - - -	1,500
	$32,600

Brought forward, - -	$32 600
Works that cannot be done by contract, supposed to cost:	
Blasting, - - - - - - -	2,000
Ropes, blocks, and tools, - - - -	1,700
Pent stock, tail races, &c., - - - - - -	2,000
Day laborers on small trestles—thirty hands 150 days, @ 75 cts. per day,	3,375
Day laborers on big trestle—sixty hands 150 days, @ 75 cts. per day,	6,750
	48,425
Contingencies, - - - - -	1,575
	$50,000

The Yahoola works can be constructed as estimated above.
(Signed), B. HAMILTON.

ART. IV.—MINERAL RESOURCES OF JAPAN.

[*Extract from a paper read by Mr. Laurence Oliphant on Japan, in the Geographical section of the British Association at Aberdeen.*]

FROM the little we know of the internal resources of Japan, it is probable that we should find a more profitable source of trade in its mineral than in its vegetable productions. Unless we have been totally misinformed, these former are of vast extent and great value. We know that the principal profits of the early Portuguese settlers were derived from the export of gold and and silver. So lucrative was it that KINIPFER remarks, "It is believed that, had the Portuguese enjoyed the trade of Japan but twenty years longer, upon the same footing as they did for some time, such riches would have been transported out of this Ophir to Macao, and there would have been such a plenty and flow of gold and silver in that town, as Sacred Writ mentions there was at Jerusalem in the times of Solomon." At a later period the Dutch carried on this same traffic to so great an extent that a native political economist, writing in 1708 on the subject, computes the annual exportation of gold at about 150,000 cobaugs; so that in ten years the empire was drained of 1,500,000 cobaugs, or about two millions and a half sterling. The gold is found in various localities. That procured from Sado has the reputation of being the finest, and it is stated that the ore will yield from one to two ounces of fine metal per one and a quarter pounds. The mines in Garouga are stated to be very rich, the copper

ore raised also being impregnated with gold. The ore from Satsuma yields from four to six ounces per one and a quarter pounds. These are the principal mines. Gold dust is found in some of the streams. Copper is superabundant, as is evident from the lavish use made of it for ornamental purposes. For a long period the Dutch received at Nagasaki, in exchange for their merchandise, Japan copper. This, however, as well as the sale of gold, has been stopped for many years. The government allows no more copper to be produced now than is absolutely necessary for home consumption, which is comparatively very small. It will be for us now to develop more fully one of the most important elements in the wealth of this vast empire. By the treaty recently concluded, gold and silver coins may be exported from Japan, but not as cargo. The exportation of copper coin, as well as copper in bars, is prohibited, but the government engages to sell from time to time, at public auction, any surplus quantity of copper that may be produced. Iron abounds in various parts of Japan, the mines of which are extensively worked—much more so at present than those of copper. Judging of articles of casting of their own construction, the ores must be of excellent quality. Specimens of wrought iron, cast and blister steel, have been examined with very satisfactory results. The wrought iron is usually hammered, and in small flat bars, varying from 12 to 20 lbs. each. This is probably to be attributed to a want of proper machinery for heavier bars, and its being better suited to their purposes. The steel, of which the swords were composed which are procured at Yeddo, was of admirable temper and quality. I have already alluded to the local mines which exist in the island of Kinsui—one of them is distant only seven miles from Nagasaki. They are a government monopoly. Hitherto the coal brought for sale since the opening of trade at Nagasaki has been surface coal, and consequently inferior in quality; it is described as small. It burns slaty, leaving considerable ash, and is very light. There can be little doubt that good coal is to be found in the island when the mines begin to be properly worked. By the treaty of Yeddo, coal, zinc, lead and tin are to be exported at a duty of 5 per cent.

Art. V.—THE SILVER HILL MINE, NORTH CAROLINA.

[*Communicated for the Mining Magazine.*]

This property is situated at Silver Hill, Davidson Co., North Carolina, ten miles south of Lexington,—which, by a continuous chain of Railway, is reached in 39 hours from New York—and consists of $1003\frac{49}{100}$ acres of land in fee simple (free of incumbrances), containing over 2000 yards of metallic veins. It is now owned and worked by the Silver Hill Mining Company, organized under a charter granted by the Legislature of North Carolina, with an authorized capital of one million of dollars.

The site of the mining establishment presents many advantages as regards surface, drainage, and general convenience for business operations; occupying a small rise or hill, and being surrounded by large tracts of woodland, whence, at moderate cost, the necessary fuel is obtained.

The buildings belonging to the Company, consist of a residence for the Superintendent, offices, laboratory, mill, engine and boiler houses, carpenters' and blacksmiths' shops, tavern and dwelling houses,—rented to miners,—negro cabins, a storehouse, and steam saw-mill ; the latter furnishing all the timber necessary for the operation of the mine. There are two steam engines, one of 80, and the other of 15 horse power, daily employed ; the first in working the pumps and driving the stamps, the second, in moving the buddles and other light work. At present there are 18 heads of stamps, and ten buddles, with the requisite machinery for dressing the ore for market. Arrangements are in progress for adding 12 stamps, which, when completed, will materially increase the product of dressed ore.

There are two shafts in use ; one, the engine shaft, 10 ft. 6 in. by 6 ft. 2 in., divided into three compartments, and sunk 160 feet ; the other, the whim shaft, 6 ft. by 5 ft. sunk vertically through the rock, and, like the engine shaft, cutting through the east and west veins, following the dip of the latter, on the underlay from the 160 ft. level to the depth of 300 feet.

The present workings have developed two regular and powerful veins, running parallel, and traversing the property

in a course north, 20° east, and dipping westerly 35° ; or 4 ft. 2 in. to the fathom, though at the 250 the dip is more perpendicular. The course of the veins has been further proved by two other shafts, one sunk at a point 320 ft. north of the whim shaft, striking the vein by a cross cut at a depth of 62 feet, and another sunk about 500 feet south of the whim shaft, which is down about 60 feet, whence a cross cut of 60 foot also, strikes the vein.

The quantity of water in the mine is not great, and is raised from the bottom level through the whim shaft to the 200 foot level, where it flows into a sump or cistern, thence it is lifted to the 160 ft. level, runs along the cross cut to the engine shaft, through which it is pumped up into a cistern raised some height above the surface, and is of value in washing the pulverized ore.

The following is a report on the underground workings, and shows what has already been done in developing the mine.

The whim, or working shaft, has been sunk on the underlay of the east vein from the 160 to the 300 ft. level. In this vein, nearly all the ore above the 250 has been taken out, except a small stope rising from the level south, and such ore as is required to protect the shaft. Between the 250 and 300 there is an entire back standing, south of the shaft, of rich lead ore, 50 feet long and 50 feet deep, and of an average thickness of 10 feet. North of the shaft at the same level, there has been a similar back, about half of which has been stoped down. South, the vein runs into slate at 50 feet from the shaft. North, at 60 to 70 feet from the shaft, there is still good ore in the end of the 300, some 10 to 20 feet beyond the winze, in which is seen turning westward, a shoot of white ore, which is characterized as carrying more or less sulphuret of silver, and is here generally found to lead to deposits of this metal either as a sulphuret or in its native state. The hanging wall of the backs before alluded to is found covered with a similar white ore, but containing a larger proportion of silver, and in the stope north of the shaft, from which considerable ore has been taken, quantities of native silver have been found mixed with rich argentiferous galena. This is also the case south of the whim, between the 250 and the 300, and indicates that the whole hanging wall of this back is similarly covered. The ore at the bottom of the 300 is of the same character as that from the 250 down, but is much richer in

galena. Vuggs containing sulphuret of silver are also seen here, and there is good reason to expect from the appearance of the vein at this, the lowest point yet reached, that it will continue at least the same in extent, and become even richer in silver and lead as the sinking is extended. It should also be stated that crystals of mundic are interspersed through the veins, while so much foliated silver has already been found at various times as to materially increase the value of the returns.

On the west vein, the lode is being stoped down from the 160 to the 250, commencing about 70 to 80 feet south, and running down to the shaft at the 250—this is the only ore standing above this level; below, no work has been done, beyond cross cutting into the east lode at the 250 and 300, showing a good course of ore at this depth, and that there are large masses standing upwards to the 250. The west lode is less rich in galena, in silver, and in gold, than the east lode, and is largely mixed with zinc ore; but as in the east vein the zinc has given place to lead, it is fair to infer that the same change will take place here. A good indication is presented just now at the 300, driving south on the east vein, in the shape of a quick flow of water, which probably comes from some loose mineral deposit in the immediate neighborhood, probably consisting of argentiferous galena or sulphuret of silver. There is sufficient ore in sight to last for years. Sinking is commenced on the east vein, and by the system adopted will be opened faster than it is stoped out.

North of the present hoisting shaft, something over 300 feet, the shaft known as the Symons shaft is sunk to a depth of 62 feet, at which point, and above, several cross cuts have been driven to the vein and levels on it, which demonstrate a continuation of the lode to, and beyond this point. From this depth, viz., 62 feet, the shaft has been sunk to a depth of 115 feet. At 90 feet a level has been driven south, on the course of the vein, and a few feet from the shaft the vein of ore has a width of seven feet.

In the present position of the mine, the ore is raised to the surface through the whim shaft, where it is broken by heavy rollers, and then thrown under the stamps. After being sufficiently pulverized, it is passed into the buddles, which separate the lead from the zinc ore and other impurities. The lead ore finds a market at McVickar's smelting works on Staten Island at about $130 per ton for 30 tons per month, which is about the present capacity of the dressing machinery.

What must be considered a valuable feature of this property is the zinc blende, which, thus far, has not been availed of to produce revenue. Of this ore, pulverized and dressed to about 44 per cent. in course of preparing the lead ore for market, there are now on the surface from 8000 to 12,000 tons—the result of four years' working. The present monthly production is equal to 350 tons. It is understood that this ore being dressed up to 55 per cent., which can be done at the mine at a trifling expense, is readily saleable in Europe, in any quantity, offers having been received of £4 10s. per ton by sample, which would leave a large profit to the company after paying all the necessary expenses.

During some recent explorations, a vein carrying gold has been discovered, but, as yet, beyond driving about 50 feet on the vein, nothing has been done to determine its value.

The machinery is in good working order, and the shafts well timbered and secured.

Art. VI.—ON THE MANUFACTURE OF MALLEABLE IRON AND STEEL.*

By Mr. Henry Bessemer.

[*From a Paper read before the Institution of Civil Engineers, London.*]

Attention was directed, in the early part of the Paper, to the ordinary mode of manufacturing iron by the puddling process; in the course of which the iron, after it "came to nature," was gathered into balls, and was then removed, as quickly as possible, to the squeezer, where much of the fluid scoria, with other mechanically mixed impurities, was driven out, leaving a mass or billet of iron, composed of thousands of separate fragments of metal, the entire surface of every one of which was, more or less, coated with dry oxyd, or fluid silicate of the oxyd of iron. The great pressure exerted by the squeezer, sufficed to so far remove the fluid coating of the contiguous particles as to bring their surface into actual con-

*From the London Artizan, July, 1859.

tact, and consequently to effect a union at such parts. But the whole of the matter thus displaced could not find its way between the interstices of the mass, and therefore it became locked in its numerous cavities, producing points of weakness and separation in the metal. No amount of after working, or rolling, could wholly displace the portions of cinder, dry oxyd of iron, and of sand, which thus became mixed up with and were diffused throughout the mass, causing flaws and cracks in the iron, all, more or less, objectionable.

Now, if these imperfections were the natural and inevitable consequences of the conditions under which malleable iron was at present produced, it followed that defects of a similar character must also of necessity exist in steel produced by the puddling process. The granular condition of the metal, and its exposure to heat and oxygen, could not fail, in both cases, to oxydize the entire surfaces of the numerous molecules to be united into one mass; the admixture of scoria and other matters, from the furnace, was equally certain to result: and also the difficulty of bringing each particle of the metal to the same degree of decarbonization and refinement existed as in the making of iron, with the additional inconvenience arising from some portions of the metal becoming entirely decarbonized, and being converted into soft malleable iron.

Iron thus presented a most unfavorable contrast with the other malleable metals, all of which were free from sand and scoria; they had no hard and soft parts, and required no welding together of separate molecules, but they were perfectly homogeneous, and free from all mechanical admixture with foreign substances. Gold, silver, copper, zinc, tin, and lead, owed this valuable exemption from the defects universally found in puddled iron, simply to the fact that they were purified and refined in a fluid state, and while still fluid, were formed into ingots, whereby the cohesion of every particle in the mass was insured. If, then, the refining of other malleable metals while in a fluid state, and their formation into cast ingots, rendered all such metals more sound and homogeneous than iron, while it did not lessen their extreme ductility, why should iron for ever remain an exception to the general rule? It might be truly answered, that hitherto the excessively high temperature required to fuse and to maintain pure iron in a fluid state, had interposed an insuperable barrier; for the highest heat of the furnaces only sufficed to show that fluidity was a possible condition of that metal.

It need not, therefore, be a matter of surprise, that when Mr. Bessemer first proposed to convert crude pig iron into malleable iron, while in a fluid state, and to retain the fluidity of the metal for a sufficient time to admit of its being cast into moulds, without the employment of any fuel in the process, his proposition was looked upon by many as a chimera, or as the mere day-dream of an enthusiast; but it was nevertheless fully recognized and supported by many of the scientific men of the day. The same deep conviction of the truth on which the process was based, and which led Mr. Bessemer to bring it before the British Association, in 1856, had since determined him (in spite of the opinions then pronounced against the process) to pursue one undeviating course until the present time, and to remain silent for years, under the expressed doubts of those who predicted its failure, rather than again bring forward the invention until it had been practically and commercially worked; and there had been produced by it both iron and steel, of a quality which could not be surpassed by any iron or steel made by the tedious and expensive process now in general use.

The want of success which attended some of the early experiments was erroneously attributed, by some persons, to the "burning" of the metal, and by others to the absence of cinder, and to the crystalline condition of cast metal. It was almost needless to say, that neither of the causes assigned had any thing to do with the failure of the process, in those cases where failure had occurred. Chemical investigation soon pointed out the real source of difficulty. It was found that, although the metal could be wholly decarbonized, and the silicum be removed, the quantity of sulphur and of phosphorus was but little affected; and as different samples were carefully analyzed, it was ascertained that red shortness was always produced by sulphur, when present to the extent of $\frac{1}{10}$th per cent., and that cold shortness resulted from the presence of a like quantity of phosphorus; it therefore became necessary to remove those substances. Steam and pure hydrogen gas were tried, with more or less success, in the removal of sulphur, and various fluxes, composed chiefly of silicates of the oxyd of iron and manganese, were brought in contact with the fluid metal, during the process, and the quantity of phosphorus was thereby reduced. Thus many months were consumed in laborious and expensive experiments; consecutive steps in

advance were made, and many valuable facts were elicited. The successful working of some of the higher qualities of pig iron caused a total change in the process, to which the efforts of Messrs. Bessemer and Longsdon were directed. It was determined to import some of the best Swedish pig iron, from which steel of excellent quality was made, and tried for almost all the uses for which steel of the highest class was employed. It was then decided to discontinue, for a time, all further experiments, and to erect steel works at Sheffield, for the express purpose of fully developing and working the new process commercially, and thus to remove the erroneous impressions so generally entertained in reference to the Bessemer process.

In manufacturing tool steel of the highest quality it was found preferable, for several reasons, to use the best of Swedish pig iron, and, when converted into steel by the Bessemer process, to pour the fluid steel into water, and afterwards to remelt the shotted metal in a crucible, as at present practised in making blister steel, whereby the small ingots required for this particular article were more perfectly and more readily made.

It was satisfactory to know that there existed in this country vast, and, apparently, inexhaustible beds of the purest ores, fitted for the process. Of the hematite alone, 970,000 tons were raised annually, and this quantity might be doubled or trebled, whenever a demand arose. It was from the hematite pig iron, made at the Workington Iron Works, that most of the larger samples of iron and steel exhibited were made. About 1 ton 13 cwt. of ore, costing 10s. per ton, would yield 1 ton of pig metal, with 60 per cent. less lime, and 20 per cent. less fuel, than were generally consumed when working inferior ores; while the furnaces using this ore alone yielded from 220 to 240 tons per week, instead of, say 160 to 180 tons per week when working with common iron-stone. The Cleator Moor, the Weardale, and the Forest of Dean Iron Works, also produced an excellent metal for this purpose.

The form of converting-vessel, which had been found most suitable, somewhat resembled the glass retort used by chemists for distillation. It was mounted on axes, and was lined with "ganister," or road drift, which lasted during the conversion of thirty or forty charges of steel, and was then quickly and cheaply repaired or renewed. The vessel was brought

into an inclined position, to receive the charge of crude iron, during which time the tuyeres were above the surface of the metal. As soon as the whole charge was run in, the vessel was moved on its axes, so as to bring the tuyeres below the level of the metal, when the process was at once brought into full activity, and twenty small, though powerful jets of air sprung upwards through the fluid mass; the air expanding in volume, divided itself into globules, or burst violently upwards, carrying with it a large quantity of the fluid metal, which again fell back into the burning mass below.

The oxygen of the air, appeared in this process, first to produce the combustion of the carbon contained in the iron, and at the same time to oxydize the silicum, producing silicic acid, which uniting with the oxyd of iron, obtained by the combustion of a small quantity of metallic iron, thus produced a fluid silicate of the oxyd of iron or "cinder," which was retained in the metal. The increase of temperature which the metal underwent, and which seemed so disproportionate to the quantity of carbon and iron consumed, was doubtless owing to the favorable circumstances under which combustion took place. There was no intercepting material to absorb the heat generated, and to prevent its being taken up by the metal, for heat was evolved at thousands of points, distributed throughout the fluid, and when the metal boiled, the whole mass rose far above its natural level, forming a sort of spongy froth, with an intensely vivid combustion going on in every one of its numberless, ever-changing cavities. Thus, by the mere action of the blast, a temperature was attained in the largest masses of metal, in ten or twelve minutes, that whole days of exposure in the most powerful furnace would fail to produce.

The amount of decarbonization of the metal was regulated with great accuracy, by a meter, which indicated on a dial the number of cubic feet of air that had passed through the metal; so that steel of any quality and temper could be obtained with the greatest certainty. As soon as the metal had reached the desired point (as indicated by the dial), the workmen moved the vessel, so as to pour out the fluid malleable iron, or steel, into a founder's ladle, which was attached to the arm of a hydraulic crane, so as to be brought readily over the moulds. The ladle was provided with a fire-clay plug at the bottom, the raising of which, by a suitable lever, allowed the fluid metal to descend in a clear vertical stream into the

moulds. When the first mould was filled, the plug valve was depressed, and the metal was prevented from flowing until the casting ladle was moved over the next mould, when the raising of the plug allowed this to be filled in a similar manner, and so on until all the moulds were filled.

The casting of large masses of a perfectly homogeneous malleable metal into any desired form, rendered unnecessary the tedious, expensive and uncertain operation of welding now employed wherever large masses were required. The extreme toughness and extensibility of the Bessemer iron was proved by the bending of cold bars of iron, 3 ins. square, under the hammer into a close fold, without the smallest perceptible rupture of the metal at any part; the bar being extended on the outside of the bend from 12 inches to 16¾ inches, and being compressed on the inside from 12 inches to 7¼ ins., making a difference in length of 9½ ins., between what, before bending, were the two parallel sides of a bar 3 ins. square. An iron cable consisting of four strands of round iron, 1½ in. in diameter, was so closely twisted, while cold, as to cause the strands at the point of contact to be permanently imbedded into each other. Each of these strands had elongated 12½ inches in a length of 4 ft., and had diminished one-tenth of an inch in diameter, throughout their whole length. There were also exhibited some steel bars, 2 ins. square, and 2 ft. 6 ins. in length, twisted cold into a spiral, the angles of which were about 45 degrees; and some round steel bars, 2 ins. in diameter, bent cold under the hammer, into the form of an ordinary horse-shoe magnet, the outside of the bend measuring 5 ins. more than the inside.

The steel and iron boiler plates, left without shearing, and with their ends bent over cold, also afford ample evidence of the extreme tenacity and toughness of the metal; while the clear even surface of the railway axle and piece of malleable iron ordnance, were examples of the perfect freedom from cracks, flaws, or hard veins, which formed so distinguishing a characteristic of the new metal. The tensile strength of this metal was not less remarkable, as the several samples of steel tested in the proving machine, at Woolwich Arsenal, bore, according to the reports of Colonel Eardley-Wilmot, R. A., a strain varying from 150,000 lbs. to 162,000 lbs. on the square inch, and four samples of iron boiler-plate from 68,314 lbs. to 73,100 lbs.; while, according to the published experiments of

Mr. W. Fairbairn, Staffordshire plates, bore a mean strain of 45,000 lbs., and Low Moor and Bowling plates, a mean of 57,120 lbs. per square inch.

There was also another fact of great importance in a commercial point of view. In the manufacture of plates for boilers and for ship-building, the cost of production increases considerably with the increase of weight in the plate; for instance, the Low Moor Iron Company demanded £22 per ton for plates weighing 2½ cwt. each, but if the weight exceeded 5 cwt., then the price rose from £22 to £37 per ton. Now, with cast ingots, such as the one exhibited, and from which the sample plates were made, it was less troublesome, less expensive, and less wasteful of material, to make plates weighing from 10 to 20 cwt. than to produce smaller ones; and indeed there could be but little doubt that large plates would eventually be made in preference, and that those who wanted small plates would have to cut them from the large ones. A moment's reflection would therefore show the great economy of the new process, in this respect; and when it was remembered that every riveted joint in a plate reduced the ultimate strength of each 100 lbs. to 70lbs., the great value of long plates for girders and for ship-building would be fully appreciated.

At a time when the manufacture of ordnance occupied so large a share of public attention, it was interesting briefly to point out the great facility which the Bessemer process afforded of forming masses, both of malleable iron and of steel, of a size suitable for the heaviest ordnance, without any welding together of separate slabs, or the more costly mode of building up the gun with pieces accurately turned and fitted together. Many attempts have been made to produce wrought iron ordnance, and this object had been successfully accomplished in the case of the large gun produced at the Mersey forge. But, however perfect this one gun might be, the time required to make it, and its immense cost, manifestly rendered it still a great desideratum to produce guns rapidly and cheaply of a material equal to or greater, in tensile strength, than wrought iron, and, if possible, free from the liability which that material had to flaws and to deterioration, during its long exposure to a welding heat. It was believed that the Bessemer process supplied this desideratum, as masses of cast malleable metal could be produced of 10 or 20 tons in weight

in a single piece, and two or three such pieces might be conveniently made by the same apparatus in one day. The metal so made might be either soft malleable iron or soft steel. In order to prove the extreme toughness of such iron, and the strain to which it might be subjected without bursting, several casks and hammered cylinders were placed cold under the steam-hammer, and were crushed down without the least tearing of the metal, as was shown by the samples exhibited. These cylinders were drawn from a round cast iron ingot of only 2 ins. greater diameter than the finished cylinder, and in the precise way in which a gun would be treated; they might, therefore, be considered as short sections of an ordinary 9-pounder field-piece. The tensile strength of the samples, as tested at the Royal Arsenal, was 64,566 lbs. per sq. in., while the tensile strength of pieces cut from the Mersey gun gave a mean of 50,624 lbs. longitudinally, and 43,339 lbs. across the grain; thus showing a mean of 17,550 lbs. per sq. in. in favor of the Bessemer iron.

If it was desired to produce ordnance by merely casting the metal, the ordinary founding process might be employed with the simple difference, that the iron, instead of running direct from the melting furnace into the mould, must first be run into the converting vessel, where in ten minutes it would become steel, or malleable iron, as was desired, and the casting might then take place as in the ordinary manner. The small piece of ordnance exhibited served to illustrate this important manufacture; and it was interesting, in consequence of its being the first gun that was ever made in malleable iron without a weld or joint. The importance of this fact would be enhanced when it was known that conical masses of this pure tough metal, of from 5 to 10 tons in weight, could be produced at Woolwich at a cost not exceeding £6 12s. per ton, inclusive of the cost of pig iron, remelting, waste in the process, labor, and engine power. The conical ingots, being cast in iron moulds, the great delay in moulding in loam would be avoided; and as the iron moulds employed might be removed from the casting-pit within an hour after the metal had been poured into them, the tedious interval of three days now required by the cast iron guns before removal would be also avoided, thus immensely increasing the capabilities of the foundry.

If it was assumed that these advantages were about equal

to the cost of hammering the cast ingot, then, by this process, it would be practicable to produce guns of any size, in hammered cast steel, or malleable iron, ready for the boring mill, at about the same cost as the cast iron guns now in use ; but if the weight of the guns could be reduced by 20 or 25 per cent., in consequence of their superior strength, then an actual saving in that proportion would be effected in the first cost of every gun so made. These important facts had been laid before the government, and their advantages were stated to be fully appreciated by Colonel Eardley-Wilmot, the Superintendent of the Royal Gun Factories, who had evinced a great interest in the progress of the invention from its earliest date, and to whose kindness the author was indebted for the many valuable trials of the tensile strength of the various samples of metal that have been submitted for investigation.

It would be interesting to those who were watching the advancement of the new process to know that it was already rapidly extending itself over Europe. The firm of Daniel Elfstrand & Co., of Edsken, who were the pioneers in Sweden, had now made several hundred tons of excellent steel by Bessemer's process. Another large manufactory had since been started in their immediate neighborhood, and three other companies were also making arrangements to use the process. The authorities in Sweden had fully investigated the whole process, and had pronounced in favor of it. The large steel circular saw plate exhibited was made by Mr. Göranson, of Geffle, in Sweden, the ingot being cast direct from the fluid metal, within fifteen minutes of its leaving the blast furnace. In France the process has been for some time carried on by the old established firm of James Jackson & Son, at their steel works, near Bordeaux. This firm was about to manufacture puddled steel on a large scale. They had already got a puddling furnace erected and in active operation, when their attention was directed to the Bessemer process, the apparatus for which was put up at their works last year ; and they were now extending their field of operations by putting up more powerful apparatus at the blast furnaces in the Landes. There were also four other blast furnaces in the south of France in course of erection, for the express purpose of carrying out the new process.

The irons of Algeria and Saxony had produced steel of the highest quality.

Belgium was not much behind her neighbors; the process was now being carried into operation at Liege, where excellent steel had been made from the native coke iron: while in Sardinia preparations were also being made for working the system. Russia had sent to London an Engineer and a professor of chemistry to report on the process, and Professer Müller, of Vienna, and M. Dumas and others from Paris, had visited Sweden, to inspect and report on the working of the new system in that country.

The Bessemer process might therefore be now fairly considered an accomplished commercial fact, and in a country like England, where the manufacture of iron and steel formed so important a branch of the national industry, and was so necessary an element in all the great manufacturing operations, it must be admitted that an impartial examination of the new system was of the highest importance, not only to those immediately concerned in the production of malleable iron and steel, but to the country generally.

That the process admitted of further improvement, and of a vast extension beyond its present limits, the author had no doubt; but those steps in advance would, he imagined, result chiefly from the experience gained in the daily commercial working of the process, and would most probably be the contributions of the many practical men who might be engaged in carrying on the manufacture of iron and steel by this system. Hitherto the process had been brought into its present practical and commercial state, without recourse to any of the numerous inventions which were supposed by the several authors to be essential to the success of the system; but any real improvement that might be brought forward would be cordially received and encouraged.

ART. VII.—THE UNION CONSOLIDATED COPPER MINES OF TENNESSEE. BY PROF. CHARLES U. SHEPARD.*

To ALONZO J. WHITE, ESQ., *and the Directors in Charleston of the Union Consolidated Mining Company of Tennessee.*

GENTLEMEN :—Before attempting a statement of the present condition and prospects of the property in which you are interested at Ducktown, I must trace succinctly the manner in which the ores occur, and the geological position generally of the mines. They occupy an isolated and remarkably well defined basin-shaped area, from 12 to 15 miles long, by five to six broad, perched two thousand feet in elevation above the level of the ocean, among the western spurs of the Alleghanies in Polk county. The mountains by which this basin is environed attain to nearly double this height. The longitudinal axis of the depression is nearly northeast and southwest, corresponding to the general trend of the mountains in this region ; and the surface of the basin is gently undulating, with hills of moderate elevation (from one to two hundred feet) which rarely exhibit outcropping masses of rock, and the basin is traversed by numerous creeks falling into the Ocoee river, as this stream crosses the region at right angles to its length, to find its outlet through a narrow chasm of the mountains on their western rim or boundary.

The geological formation of the country is familiarly known as primary, consisting of an interchanging series of micaceous, chloritic and talco-chloritic, micaceous slates, sometimes interlaminated with gneiss, hornblende-rock, and more rarely, by extensive quartz veins. This is particularly the structure of the basin ; and with slight variations, that, also of the contiguous mountains. These slaty rocks are not placed directly on end, where their thin, sharp edges are occasionally seen coming to the top of the ground ; but they pitch off, or dip to the southeast, at an angle, varying between 50° and 70° ; that is to say they are more than half raised towards a perpendicular or vertical position.

* Reprint of the "*Report of* Prof. CHAS. UPHAM SHEPARD, *on the Ducktown Copper Region and the Mines of the Union Consolidated Mining Company of Tennessee.* 8vo, pp. 8. Charleston, 1859.

This being the general structure of the region, it remains to point out the character of the metaliferous layers or veins. These are two in number (possibly three) running with the strata, or enclosing rock layers, from northeast to southwest, through the entire length of the basin, and situated from a quarter to a half a mile asunder. An idea may easily be formed of their position, by placing a thick folio volume at the angle of stratification above mentioned, with its back in a horizontal position, the opening edges of the book being arranged northeast and southwest. Let the slope, or falling off of the sides be to the southeast. Now insert two bundles of pasteboard (each containing half a dozen leaves) between the leaves of the volume, and separated from each other by four hundred leaves of the book. The upper surface of the book with its included veins of pasteboard should now be moulded off so as to simulate the surface of our great copper-field, with its broken swells of land, and creeks, and we arrive at a very tolerable conception of the general features of this remarkable region. It must be conceded, however, that there are some curvatures and partial breaks in the veins, and that indications are not wanting of other courses of ore, exterior to the main veins, and possibly in a few cases transverse to them.

The thickness of the veins varies from five to twenty feet, occasionally bulging out, however, to a much wider limit. They are largely filled with iron and copper pyrites (*mundic* and yellow *copper*), the former species vastly preponderating, and, in general, forming nearly the whole contents of the vein; in which case it is excessively hard and solid, presenting the aspect of bronzed metal. It is usually known in this condition among the miners of the region under the name of "*arsenical ore*," a circumstance much to be regretted, since this term conveys an entirely erroneous idea of its nature. Having examined it with care, I am satisfied that it is wholly free from arsenic; and that aside from the small but variable proportion of yellow copper present, it consists of iron 63.60 and sulphur 34.40 in every one hundred parts. It is therefore what is known as magnetic iron-pyrites (the *pyrrhotine* of mineralogists).

Such is the leading character of the metallic veins below the levels at which they are subject to natural drainage, or, in other words, below the water level of the basin. By the

water level, however, must not be understood a perfectly horizontal plane, cutting the tops of the veins. It is rather an undulating floor of much irregularity, ten, twenty, thirty, or forty feet higher in some places than in others, and varying still more in its distance from the surface of the ground, dependent upon the undulations above alluded to in that surface. Upon this irregular surface of the hard, unaltered veins, as upon a floor, was found almost everywhere, so far as they have been sunk upon, an accumulation of black, sooty pyritous (or sulphuretted) copper ore, varying in depth in different places, from two to six feet (sometimes even deeper), and in width from five to ten (rarely to twenty) feet. Above the black ore, to the top of the ground, the distance varies from a few feet to sixty or seventy feet, according to the shape of the surface of the country ; the distance being greatest where the land is the highest. Above the black ore, to the surface, the vein is occupied with what is called *gossan*, a cindery, ferruginous rock, much resembling the ordinary honey-comb, or bog-iron ore, and which, having been mistaken for this substance, gave rise to the discoveries of copper in the region. The black ore being worth from twelve to thirty per cent. of copper, was of course first worked upon, and has already been removed from several portions of the veins. The obstacles encountered in excavating this material were slight, and its richness was sufficient to overcome the drawbacks incident to the high price of mining labor, and the want of facilities for reaching a market for the produce of the mines. Thus bountiful was nature in providing inducements to enterprise in this remote and seemingly inaccessible region.

An explanation of the condition in which the black ores are found upon the tops of these veins suggests itself at once to the attentive observer. We see about the smelting furnaces vast heaps of pyritous ore, in the shape of wood, piled for the purpose of burning into charcoal, undergoing the slow process of atmospheric roasting, preparatory to the operations of the furnace. In these piles, the masses of ore are thrown (to the depth of eight feet) upon a few logs of wood. The wood is kindled, thereby affording a temporary bottom-heat. Sulphur fumes pass off, and the whole mass begins to heat and ferment. Chemical changes (too numerous and intricate to be here unfolded) transpire, whereby the heat is maintained. These are promoted and increased by rains, and the ferment-

ation continues for weeks, or even months, until at last the central and bottom portions are found to contain all the rich copper ore, in the condition of a sooty, pulverulent and vitriolic mixture, while the surface of the heap is a ferruginous cindery mass. This is a microcosm of what for thousands of years has been going forward in the outcrops of the veins. And the reason why the transformation has not descended lower into the veins has probably been that a sufficiently elevated temperature for a continuation of the process has been arrested by the presence of water. All the ore situated above the level of about 55° or 60° Fah. has in this way suffered fermentation; and the great bulk of its copper has been converted into what may be considered newer, or secondary ores, such as black oxyd of copper, black sulphurets, with occasional admixtures of red oxyd, native copper, and green carbonate and sulphate of copper; ores which will not be found, except incidentally, in the unaltered iron and copper pyrites below.

Whether the unusual thickness of the black ore at particular places is ascribable to an immediately superincumbent mass of rich yellow copper is not certain; for in the leaching process, the copper has been largely brought into solution by conversion into blue vitrol (sulphate of copper), and may have been conducted along obliquely to a considerable distance from its original repository, before the precipitation of the black copper ensued. Besides, in many places, we are led to suppose that much of the solution made its escape before letting fall the copper, and ran off in the surface waters of the country to the Ocoee river. Still it is reasonable to suppose, from the extreme irregularity in thickness and breadth of these secondary ores, that a somewhat corresponding irregularity prevailed in the cupreous richness at different points along the original outcrops of the veins. Indeed, explorations now beginning to be made in the hard, unaltered veins below, tend to confirm this opinion.

If the view here presented be correct, the means are to a certain extent at hand for enabling us to estimate the quantity of black ore still remaining in your mines. From the best opportunities placed within my reach for forming an opinion on this point, I am led to believe that much less than one half has yet been mined. Vast lines of outcrop have never so much as been sunk upon with a view to determine their richness. The rule of exploration thus far, appears to have

been to sink only where the outcropping gossan has been abundant. But it is clear that large deposits of black ore may be accumulated remote from these gossans. These await future development. Besides, several of your mines are known to contain large reserves of this rich material, some of which are now in the course of exploration, while in others, only the richer and more accessible portions of it have been removed, still leaving an abundance of that which is less concentrated, but which will amply repay removal. Add to this, I must mention the recent discovery of an entirely new vein of exceedingly rich black ore in the Mary's mine, the extent and value of which promises to be very great. Indeed I am far from certain, that more than one-tenth of the black ore has yet been brought to light in the Ducktown region ; and of this undeveloped wealth, the extent and position of the Consolidated Company's territory warrants the belief, that the largest share, by far, will fall to their possession.

But supposing the stock of black and secondary ores to be exhausted—an event no doubt destined to occur at no very distant period—we have next to consider whence the supply of workable ore is to be maintained. From an examination at several points of the unaltered primary portions of the veins, I am led to believe that a large portion will pay for mining, under the economical methods now beginning to be put in use at Ducktown for the extraction of copper ; while I am also confident that rich lodes of yellow copper will, from time to time be struck in these veins, that will make them through all time a profitable source of copper.

It afforded me great pleasure to witness the method of concentration by roasting and re-roasting in heaps in the open air, a process that requires next to no fuel, no furnace constructions, little labor, and scarcely any thing but time and the action of the elements, whereby vast heaps of cheaply raised, weak ores, in the course of from four to six months, are made to yield a rich deposit of ore, suited to a final reduction to a regulus (of from 40 to 50 per cent. copper) in the operation of a smelting furnace. There is obviously no limit to the supply of these weaker ores in the Ducktown mines.

In addition to the above resource for copper, attention is now beginning to be turned to the preservation of the blue vitriol waters of the mines and the roasting heaps, which heretofore were suffered to run waste. This water is now detained

in extensive tanks and reservoirs; and made to precipitate its copper, through the addition of scrap-iron, thereby materially adding to the returns of the mines.

But the great desideratum with your shareholders obviously is the discovery of bunches and lodes of yellow ore through the mundic. That these discoveries will be made is perfectly certain. As a confirmation of this, I am happy to bear witness to the brilliant success of the Union Consolidated Mining Company in striking, only a few months ago, a lode of yellow ore in the East Tennessee Mine. Its extent is not yet ascertained; but its average width is nearly twenty feet. I examined the course of outcropping gossan upon the vein for a distance of nearly one-fifth of a mile, throughout a good portion of which, it may prevail, in linear extension; while its depth may doubtless be calculated upon for hundreds of feet if not of fathoms. Large heaps of the produce of this discovery are accumulating at the mouth of the shaft, and a tunnel of three hundred feet is nearly completed, by which the vein will be struck at eighty feet in depth, and unwatered for a great extent of the vein. The ore brought to surface will produce already from twelve to fourteen per cent. of copper, and increases in richness with the depth.

Another similar but less affluent bunch of yellow ore has been struck in the Mary's mine, by means of a tunnel or adit lately put in, upon the vein, twenty feet below the deposit of black ore.

Your company may therefore be said to have entered upon a new era in the working of their mines in these discoveries of rich primary ores, which are destined to be lasting sources of prosperity to the enterprise.

Our knowledge of the general laws which govern the occurrence of the metallic ores, permits us to anticipate that the careful examination of the tops of the veins, where the ore is in its primary condition, will bring to light, at no distant day, many similar lodes and deposits within your extended territory, and I allow myself to believe that the Ducktown mines will not be eclipsed in ultimate value to their proprietors and the country, by any now known within the limits of the United States.

Too much praise cannot, in my opinion, be awarded to the thoroughly practical manner in which the whole business of mining and smelting has at last come to be conducted at your

mines. Every arrangement, below and above ground, bespeaks not only science and skill, but what is also important, a singular avoidance of untried schemes and all those innovations upon settled experience which have too generally been the bane of mining enterprises in this country.

If an inexhaustible supply of ore, a fair possession of the advantages of a genial climate, of abundant agricultural supplies and cheap labor, added to the fruits of hard-earned experience and superior mining and metallurgic direction, can constitute guarantees of success, then I feel safe in saying that the Union Consolidated Mining Company of Tennessee can never fail.

Very respectfully, your obedient servant,

CHARLES UPHAM SHEPARD.

CHARLESTON, April 8, 1859.

MINING AND SCIENTIFIC INTELLIGENCE.

GEOLOGY.

Progress of the Geological Survey of Texas.—We have just received the *First Report of the Progress of the Geological and Agricultural Survey of Texas*, By B. F. SHUMARD, State Geologist. This is a pamphlet of 17 pages, under date of December 1st, 1859, and contains a general statement of the progress of the Survey, with some of the leading results. The party was organized by the appointment of Geo. G. Shumard, M.D., Assistant Geologist; and Prof. W. P. Riddel, Chemist and Assistant Geologist. The field operations commenced in January, 1859, and were brought to a close on the 1st of November. Since that time, the several members of the corps, have been actively engaged in the Geological Rooms and Laboratory unpacking, arranging, and examining the large amount of material that has already accumulated. It is proposed to spend the winter months in these examinations.

The State of Texas, occupying nearly half of the breadth of the Continent, or extending from the central chain of mountains to the sea-board, presents a broad and most inviting field for the Geologist

and Palæontologist. Nearly all the formations from the base of the Palæozoic to the latest Tertiary, are there represented; though the strata of the Secondary and Tertiary periods, replete with their characteristic organic remains occupy, by far, the greatest portion of the area.

The operations of the survey appear to have been planned and executed, so far, upon a scale and with a vigor commensurate with the magnitude of the undertaking. The plan of surveying by counties, preceded by preliminary general surveys, has been adopted. Such explorations have already been extended over a considerable portion of Eastern and Middle Texas, and seven lines of section, varying in length, from 100 to 256 miles, have been surveyed. Minute and final surveys have been made of eleven counties; two are nearly finished, and a number have been partially surveyed.

Results of the highest interest and importance to the State, have already been obtained. We extract the following observations upon the extent of the Texas coal-field:

"Our partial explorations show the existence of an extensive coal formation in the northern part of the State, that will exercise a most important influence on her future welfare and prosperity. We are not now able to define the precise boundaries of the Texas Coal Measures. To do this with precision, would require a much more detailed investigation than the limited time at our disposal has permitted us to make. It may, however, be stated as a reasonable estimate, that the area occupied by the coal strata, can not fall short of four or five thousand square miles. Taking Fort Belknap as a starting point, we have found this formation to extend uninterruptedly southeastwardly to Patrick's Creek, in the southwest part of Parker County, a distance of more than sixty miles; westwardly, about forty miles; and southwardly, beyond Camp Colorado, in Coleman County, say one hundred miles.

"Mr. Marcou in his '*Carte Geologique des Etats Unis*,' has attempted to define the limits of our Coal Measures. But the boundaries laid down by him are incorrect, and liable to lead to serious error. The Coal Measures do not extend into Grayson, Fannin, Collin, and Dallas Counties, as represented in that map.

"The Strata composing the Coal Measures of the region we have described, have a thickness estimated at not less than three hundred feet, and consists of quartzose and argillaceous sandstones, limestones, grits, and conglomerates; argillaceous and calcareous shales, fire, potters', and pipe-clays, and coal. Some of these strata, and particularly the limestones and shales, are filled with organic remains; among which we have recognized many species which are characteristic of the Coal Measures of Missouri, Kentucky, Illinois,

and Iowa. The shales, also, frequently contain large and beautiful crystals of selenite and rounded masses of excellent iron ore. The coal, at all of the localities examined, reposes either on fire-clay, or shale. In Young and Buchanan Counties, outcrops of coal occur at a number of points; and in the former county, it has been struck at many places, in excavations for wells. We have here recognized four distinct coal seams, varying from six inches to five feet, and presenting an aggregate thickness of eight or nine feet. At the mouth of Whiskey Creek, near Fort Belknap, is an interesting exposure exhibiting three distinct coal-beds, separated by bands of limestone, fire-clay, sandstone, and shale; and the whole surmounted by sandstone and conglomerate.

"In regard to the quantity, we do not speak in extravagant terms, when we assert that in the region under consideration, there is an abundance of this most valuable mineral fuel, to supply the present and future demands of the State for centuries. With reference to the quality of the Texas coal, it may be stated that it will compare favorably with most of the coals which are wrought in Missouri, Illinois, and Iowa. In general appearance and weight, it resembles very closely the coal of St. Louis, Missouri, and Belleville, Illinois.

"Besides the coal area just described, it is highly probable that productive coal-beds will be discovered in the extreme western part of the State. This opinion is founded upon an interesting group of fossils from the Hueco Mountains, and a part of the Guadalupe Range, which were obtained by Dr. Geo. G. Shumard, while connected with the expedition of Capt. Pope. In this collection, I have found, with some forms that are undescribed, quite a number of well-marked species of the Coal Measures."

Prof. Shumard also describes extensive beds of brown coal or lignite occurring in the Tertiary. It is said to underlie a large portion of Rusk Co.

"The beds examined, vary from six inches to eight feet in thickness, and are associated with bituminous shale, fire, and potters' clay; soft quartzose, and argillaceous sandstone, impure limestone, and iron ore.

"At a number of localities visited, the lignite appears to be of good quality and adapted for the ordinary purposes of fuel. It varies greatly in character in different sections of the county; some specimens exhibiting the woody fibre with tolerable distinctness, while others show no traces of organic structure, being dull, shining-black, and very compact in texture.

"In the N. E. corner of Cass County, at 'Stone Coal Bluff,' examined by Dr. G. G. Shumard, there is a bed of lignite, ten feet thick, which resembles the bituminous coal of Fort Belknap, both in external character and chemical composition; and it is quite probable that it may be employed to advantage in the manufacture of iron."

Petroleum has also been found by the Survey, and it is said to occur at several points in the State. The most important locality visited, is at Sour Lake, in Hardin County, where it occurs on the surface of remarkable acid springs adjacent to the lake. The earth for some distance around these springs, is so highly charged with bitumen, as to be employed for purposes of illumination, and to some extent, as fuel. Such a locality is worthy of exploration: a supply of mineral oil might be obtained by boring.

One of the most important results of the Survey, is the discovery of an immense iron region in the eastern part of the State, embracing considerable areas in Cass, Harrison, Rusk, Panola, Smith, San Augustine, and Shelby Counties. The ore is chiefly limonite, and is from the Tertiary.

"According to Dr. G. G. Shumard, Cass County alone is capable of supplying a number of furnaces with an abundance of excellent iron ore for many years. The ore occurs here in regular layers, which sometimes attains a thickness of fifty feet. The only iron furnace our State can boast of, is located in this county. It was erected several years since by Mr. Nash, and has been in nearly constant, and, I believe, profitable operation up to the present time. The ore is mined near the furnace; and the kinds preferred are a porous variety of hematite, termed by the proprietors 'Honey-comb ore,' and compact brown hematite. The pig metal and castings produced from these ores, are of excellent quality, and commands a high price in the market."

Specimens of lead ores have been received by the Survey from different parts of the State, inducing the belief that future explorations may develop the existence of valuable veins. Molybdate of lead, is said to occur in abundance in Llano County. This is a rare mineral, and interesting to mineralogists. We hope to hear more facts regarding it. One of the specimens of galena yielded by assay, at the rate of nine ounces of silver to the ton; this, however, is not rich enough to justify working for silver in that region.

Texas, considering its great extent, can not be regarded as rich in minerals; the geology of a large portion precludes the idea. It is pre-eminently an agricultural, pastoral State; being in these aspects and in climate more nearly like the coast region of California, than any other part of the United States. In California, however, the formations of the Coast Mountains, though probably, in great part, of the same geological periods as the plains and mesas of Texas, are more or less rich in minerals; owing, doubtless, to their dislocations and

grand wave-like foldings, and the intensity of the metamorphic action which has been exerted throughout the length of the State. The explorations in Texas, however, have not yet reached that part of the State which is probably the richest in useful ores. This portion is that between the Pecos River and the Rio Grande; and is, as yet, comparatively inaccessible within the limits of reasonable expenditure. It will afford interesting results, also, in structural geology; but its topography, climate, and the Comanches, render it undesirable as a field for exploration.

The collection of soils, clays, rocks, ores, coals, and fossils, is quite extensive; and includes an interesting specimen of meteoric iron, from the head-waters of the Brazos River, weighing upwards of 300 pounds.

The expenses of the Survey for the year, including outfit of instruments, chemicals, horses, mules, and wagons, &c., amount to $15,073.

Progress of the Kentucky Geological Survey.—Dr. D. D. Owen, the Director of the Geological Survey of Kentucky, has submitted to the Governor, a synopsis of the principal results of the Survey for 1858 and 1859.*

Since the completion of the preliminary reconnoissance of the State, the chief force of the various geological corps, has been concentrated on the coal and iron regions. The work has been done chiefly by the topographical assistants, Sidney S. Lyon, and Joseph Lesley, Jr., and by Prof. Leo Lesquereux. Prof. Lesquereux has been engaged in the palæontological department of the Survey, while Mr. Lyon and Mr. Lesley have been occupied chiefly in establishing the geographical and topographical basis for the geological work in detail.

The charge of the Survey of the eastern coal field, was committed to Mr. Lesley; and from his Synoptical Report, we learn that he has surveyed a base line along the trend of the strata, or the outcrop of the eastern coal and iron field, from Grayson, in Carter County, to the Tennessee line. The whole number of miles run is 435; of which 300 were levelled carefully with an engineer's level. This line Mr. Lesley denominates the *Outcrop base line of the Eastern Coal field*, and observes of it that:—

* *Documents accompanying the Governor's Message. Report from the State Geologist.*

" Great pains were taken to form a fixed and thorough basis for any future surveys to be made across the great eastern coal-field of the State: stations having been carefully made and bench-marks cut at the forks of every road leading to the eastward; so that at every desirable point of departure, fixed data exist, both for the starting of compass lines, and for the continuation of the levels."

Mr. Lyon has been, and is still engaged in running a base line east and west in the western coal field. When completed, this line will extend from the Ohio River, in Union County, to the Virginia line. Dr. Owen, observes of this work, that it " will be a grand object accomplished in the geography of the State; and will tend, not only to correct numerous errors in the geographical position of important places in the State, but form the principal line wherefrom to commence, close, unite and tie the local surveys of the different counties."

It will thus be seen that the survey, nominally geological, merely, is discharging a double duty in working out the geography as well as the geology of the State. The geographical results will be of the highest importance and permanent value, independent of their connection with the geology. We will now briefly notice some of the geological results.

Mr. Lesley observes that the lowest coal " extends throughout the whole length of the outcrop base line; that though this lower bed is at times, and in many places but a streak, still enough remains, in most cases, to be used for local blacksmithing, and for home consumption in the farmer's grate." 2d. That extending above the line southward from Proctor on the Kentucky river, there are two workable beds of coal proved to be good for gas-making, the grate, and in the manufacture of iron. 3d. That continuous bands of iron ore, more or less thick, accompany these beds of coal, which, at many points, could be worked in the high blast furnace to advantage and profit."

From the summary given by Mr. Lesquereux of his full Report, inedited, we learn that it is divided into three parts: the first containing palæontological, stratigraphical, and lithological descriptions of the coal strata; the second shows the place in section of each coal bank or opening, and the third part contains a short comparison of the distribution of the coal strata in Kentucky, Ohio, and Pennsylvania. Of this last part, Mr. Lesquereux says: This comparison is

of high scientific interest, as it fixes the general distribution of the coal strata in the whole extent of the coal basins of the United States, and cannot but give to the geological reports of Kentucky a great value as containing the key of the general distribution of the coal. Henceforth, all the reports treating of the distribution of coal strata will naturally take their guide and standard of comparison from the sections in the Kentucky coal fields."

Dr. Owen doubts the propriety of dividing the Kentucky coal measures into the *productive* and *barren*, as in Pennsylvania; for in the space corresponding to the barren measures, six coal beds have been found; three to five of which, are locally workable, one being "the most reliable and extensively worked coals in the whole coal measures." He observes (p. 36):

"In my report I shall give my views on this subject, and present what I consider the most natural, and practically useful classification of our coal-measures. I consider that the amount of information already presented in the previous Kentucky reports, together with the forthcoming report of Mr. Leo Lesquereux, now in manuscript, will form standard matter for reference on all subjects pertaining to the coal-measures. The fact I believe can now be fully demonstrated, that, except in the anthracite regions where the Pennsylvania coals acquire great thickness, Kentucky possesses the richest coal-measures of any State of which we have at present any precise geological data for comparison, as will be shown in the forthcoming volume."

An interesting fact was observed by Mr. Lyon—that the best lands of certain counties, always corresponded to the zone of the Silurian rocks.

The chemical work has been carried forward by Dr. Robert Peters, who reports having made the astonishing number of 528 analyses in two years. These were chiefly of soils, iron ores, and limestones.

Dr. Owen estimates that with an appropriation of $12,000 per annum, two years would now suffice to complete the work in the western coal-field, and continue the topographical surveys in the eastern; the complete survey of which would require two or three years more.

New Species of Fossils.—At one of the January meetings of the Academy of Nat. Sciences of Philadelphia, Mr. Wm. M. Gabb, presented descriptions of new species of fossils, probably Triassic, from Virginia, and of new Cretaceous fossils. Mr. T. A. Conrad has also

presented a paper entitled "Descriptions of New Cretaceous and Eocene Shells of Mississippi and Alabama, with notes on Eocene fossil shells." All of these papers have been ordered to be published in the Journal of the Academy.

IRON.

Experiments on Cast Iron.—A series of valuable experiments has recently been carried on under the superintendence of Col. F. Eardley-Wilmot, superintendent of the Royal Gun Factories at Woolwich, upon various British irons, with a view to determine the most suitable varieties for the manufacture of cast iron ordnance. The results of these experiments are printed in a tabular form in a parliamentary report lately issued. The tables occupy nearly the whole of a thick folio book, and show the strength of various specimens of iron supplied by the principal iron founders of the kingdom. when subjected to tensile, transverse, torsion, and crushing tests.

"The general results of a considerable number of such experiments are shown in the following table:—

	Specific gravity of 850 specimens.	Tensile of 850 specimens.	Transverse of 564 specimens.	Torsion of 276 specimens.	Crushing of 273 specimens.
Maximum, . .	7 340	34,279	11,321	9,773	140,056
Minimum, . .	6 822	9,417	2,586	3,705	44,563
	Of fifty-one samples.	Of fifty-one samples.	Of 53 samples.	Of fifty-one samples.	Of fifty-one samples.
General Mean, .	7 140	23,257	7,102	6,056	91,061

From the prefatory remarks to the tables we quote the following passages, which indicate some remarkable peculiarities in the condition of the specimens of iron, and the effect which a slight change of circumstances in casting produced on the strength of the metal.

"The results already obtained by various experiments on the subject of re-melting cast iron are well known, and have been repeated at various times in this department; when, however, the experiment is made with large masses of iron of several tons, the effect produced is not so marked. It would appear that without any considerable

diminution of the impurities in the metal, as silicon, sulphur, and phosphorus, a considerable increase of tenacity and specific gravity can be obtained. The graphite is partially expelled, and some of it is converted into combined carbon, and the contraction and crystallization is more energetic and complete. This combined carbon can, it is thought by some, on again re-melting the mass, and very slowly cooling it, be reconverted to graphite, rendering the iron soft and fusible. This is undoubtedly the case with the product of the refinery process known as 'metal,' the use of which on this principle formed the subject of a patent by Dr. Price in 1856.

"There is a point not probably accurately determined at which the maximum hardness corresponding to the maximum tenacity may be found. In an iron cannon there is, however, required an elasticity in addition to other qualities, when these qualities are not in excess to such an extraordinary degree as to render the mass so strong and rigid as to obviate any danger of disruption. It has been found in the various experiments made at Woolwich, that in most cases where the specific gravity is 7·3 or upwards, the metal is unsuited for gun purposes, on account of its hardness and want of elasticity; while the same iron treated in the furnace for a shorter time, and being when cast of a lower specific gravity and less tenacity, would have resisted more satisfactorily the explosion of the powder.

"The most decided features to be observed in the results are the universal and very marked superiority of the bars in the cases where they have been cast horizontally over those cast vertically; and the superiority, but in a less marked degree, of the bars cooled quickly over those cooled gradually or slowly. It is to this rapid cooling and condensation that the superior strength of a 2-inch bar cast from a portion of the metal of which a gun is made, is due.

"This is almost universally found to be the case in the experiments hitherto made with a portion of metal taken from the dead-head, close to the muzzle of the gun, as compared with the bar cast at the time of making the gun.

"The contrast as regards appearance is equally marked. In the bar a close grey rigid appearance; in the dead-head a large grain with graphitic masses joined or cemented together with a whiter and harder material.

"The demand for the manufacture of iron ordnance, and the necessity for the supply of a certain number to meet what is expected in this country of a new government establishment, has prevented such various experiments being made as are desirable. At a new government foundry on the continent, established about the same time, two years were allowed for experiments before a 'supply' was demanded. It would appear that a great deal is still to be done on this subject, and that we are only now at the commencement of vast improvements in the manufacture of cast iron and cast steel."—*London Civ. Eng. and Arch. Journal.*

Krupp's Steel Works.—The Cast Steel Manufactory of F. Krupp, of Essen, Prussia, is the largest in the world. It is situated on the skirts of the town in the midst of the coal mines, and covers, with its buildings and yards, a space 1,600 by 1,800 feet. About 1,500 men are at present employed in its various parts, and 150 tons of coal are consumed each day. The process employed for manufacturing the steel was discovered, after many expensive and laborious experiments, by Mr. Krupp, and is kept a profound secret, only a few trustworthy men being allowed to work in the room where the important mixtures are made. The method is said to be founded on the principle of melting together carbonized and decarbonized iron—cast and wrought iron—and thus obtaining a mixture which has the known composition of steel.

A mass of 10,000 pounds of cast steel was sent to the Paris exhibition. The largest shaft of the same material ever made was, when turned, 30 feet long and 10 inches in diameter, and is now in use on a French steamer, and cost $6,000, and a single piece of steel has been produced weighing 20,000 pounds.

Car-axles of steel have been largely manufactured, and Mr. Krupp binds himself to pay a penalty of $10,500 if any that he sells break within ten years. Messrs. Thomas Prosser & Sons are agents of this house in America.—*Am. Railway Review.*

The Wyandotte Rolling Mill Company.—The works of the above Company are located at Wyandotte, Michigan, a thriving town on the Detroit river, and on the line of the Detroit and Toledo Railway, 10 miles south of Detroit; also at Chicago, Illinois. The Wyandotte mills have been actively employed since December, 1856, in the manufacture of merchant bar iron, but principally in the manufacture and re-rolling of railroad iron. They have turned out to the present time over 22,000 tons of rails, of which about 12,000 tons have been laid down on the Michigan Central road, and the remainder distributed on railways in Canada, Ohio, Michigan, Illinois, and other Western States. The Company manufacture their own charcoal pig-iron, turning out 3,500 tons annually. The rail-mill at Wyandotte is capable of turning out 12,000 tons of rails annually, and the merchant mill, which has been in operation about twenty months, has a capacity for producing 3,000 tons of finished iron, yearly. An improved Nasmyth hammer is now being put up, which with other machinery also erecting, will enable the Company to manufacture locomotive tires, spikes, axles, boiler plate, etc.

The Chicago mill has been in operation about six months and has a capacity for manufacturing 12,000 tons of rails yearly. This mill has already re-rolled 1,500 tons of rails (61½ lb. pattern) for the Chicago and Burlington Railway, and large quantities for other neighboring roads. This mill, with the new machinery contemplated upon, will be as efficient as any rail-mill in the country. The Company use large quantities of Lake Superior ore, the iron from which

has already become famous for its great strength and tenacity. They employ at present, at both places, some 500 men. The address of the Secretary of the Company, W. H. Zabriskie, Esq., is at Detroit, Michigan.

Iron Ore in Indiana.—D. D. Owen, State Geologist of Indiana, reports to the State Board of Agriculture, that during progress of the survey of the State, several beds of iron ore were found, usually either interstratified with the coal measures, or near the margin of the coal basin, some of which ores evidently contain a large per centage of iron.

Iron Ore in Warren County, New Jersey.—A superior quality of iron ore has been discovered on the premises of Mr. Henry Albert, in Mansfield, Warren county.—*Phil. N. Amer.*

Franklinite Wire.—Washburn & Co. have drawn wire as fine as No. 32 from the puddled bar direct out of a mixture of 12 per cent. of Franklinite with iron.—*Railway Review.*

COPPER.

Lake Superior Mines.—We condense the following intelligence from the Lake Superior Mining journals:

MINNESOTA.—During the month of December, the Minnesota raised 360,015 pounds, or 180 tons of copper. The works of the mine were entirely suspended during the greater part of the week ending January 16, by a strike among the miners.

Several very fine pieces of copper are among the products of December. One of these was drawn to the copper house, and weighed about seven tons—but being too long to go into the furnace at the smelting works, it had to be cut in two, and did not therefore go into the account of December. This is from the mass at the bottom of No. 8 shaft. At the latest dates, several of the large masses had been further stripped, so as to expose greater proportions. The copper in sight is certainly sufficient to warrant an increase in the production for several months, unless the work is retarded, by accidents or casualties. New hoisting apparatus will soon be greatly needed at the eastern part of the mine, as the No. 6 engine is now working to four shafts—Nos. 2, 6, 10, 9.

ROCKLAND.—During the month of December, the Rockland raised 81,281 pounds, or 40 tons and 1,281 pounds. A very heavy mass was also taken out, weighing about five and a quarter tons. It was taken to the landing without cutting. The product for the year 1859, was 398 tons and 283 pounds. In this mine, the force at present is mainly employed in opening the mine, instead of taking out copper. Rich stoping ground is said to be in reserve.

NATIONAL.—Product for December, 33 tons. Masses of copper are being disclosed in different parts of the mine, among them a mammoth one, whose dimensions have not yet been ascertained. The force at present, is mainly employed in opening the mine, and yet the product is over 50 tons per month.

NEBRASKA AND OGIMA.—These mines are said to present better shows of copper than ever before.

SUPERIOR.—At the Superior, in the old Flint Steel adit, the miners are again finding small masses. About 900 pounds of copper in this form, were taken out in one day.

CARP LAKE MINE.—We have received a copy of the Report of John Hays, the Agent of this mine, and of Captain Daniel Beazer, who is now engaged upon the property, from which, and other sources, the following information is condensed:

The Carp Lake Mining Company is organized under the General Mining Law of the State of Michigan, and has its Office at Cleveland, Ohio. The property is in the County of Ontonagon, Township 51 N., R. 43 W., and includes over 900 acres of land, most of which is well-timbered, and of the best quality for agriculture. It is upon the celebrated Porcupine Ridge of trap-rock, which, at the mine, is nearly 1,000 feet high, and extends parallel with the shore of Lake Superior. The northern slope is gradual, but to the south it descends precipitously to Carp Lake.

Five or six veins have been traced running parallel, and dipping with the rocks. The Company is now sinking two shafts near the eastern end of the property. These follow the dip of the vein, as they should at this inclination (only 30°), and the ore is raised in tram-wagons. Shaft No. 2 is now down 75 feet from the surface, and No. 3, 50 feet. The vein is said to vary from two to four, and six feet in width, and to bear numerous masses and sheets of native copper, and considerable quantities of rich stamp work. The copper is chiefly found in one foot of the lower part of the vein, which is so

soft as to be very easily and cheaply worked. The hanging wall is a dark gray trap, like that of the Minnesota mine. The average of the ore is said to yield 10 per cent. of ingot copper. Native silver, in minute particles, has recently been reported.

Yield of Lake Superior Copper Mines in 1859.—In the January number of the Magazine, the yield of the Lake Superior mines, for 1859, was presented as far as obtained. The Circular of Messrs. Dupee, Beck & Sayles, before us, gives the following summary in tons and tenths, the weight of the barrels having been deducted:

Keweenaw District	1,910.3
Portage District	1,533.1
Ontonagon District	2,597.6
Total Tons	6,041.

5,995 tons reduced to ingot copper, is equal to 4,200 tons of ingot copper, worth, at $460 per ton, $1,932,000.

Copper Ore in Texas.—According to the recent Report of the Geological Survey of Texas, small, rounded masses of the oxyd and carbonate of copper occur, distributed abundantly over the surface of the country, toward the source of the Big Wichita, Brazos, and Red River. It is thought not improbable that productive veins of copper will be found in that region. Specimens of native copper have also been obtained in the western part of the State.

Copper from New-Jersey.—The Flemington (N. J.) Gazette says the Flemington Copper Company shipped twenty tons of ore on the 29th ult., and as much more on the 4th instant.

SILVER.

Washoe and Carson Valley Silver and Gold Mines.—We find in the San Francisco *Times*, a series of letters from a gentleman who has spent several months in the new mining district of Carson and Washoe Valleys. As these letters present interesting information and details, regarding the extent and character of the newly discovered veins, and appear to be the result of careful and dispassionate observation, we present extended extracts. The writer

was disposed to regard the richness of the region as very generally overrated by the press and public of California, and upon this point observes:

"To a person not present and seeing, it would seem incredible how trivial a circumstance has sometimes, in the history of these explorations, given rise to reported discoveries of what, with more irony than truth, has been termed 'fabulous wealth!' The finding of such rich silver ore at *one* point so excited the cupidity and influenced the imaginations of many who repaired to this Washoe country, that they were not only exposed to the impositions of others, but readily imposed upon themselves. Thus it was, every quartz lead found to contain any thing resembling silver ore was claimed to be rich in that mineral; even limestone and granite being sometimes mistaken for argentiferous rock. These mistakes were of course corrected before the discoverers made their fortunes, but generally not in time to prevent the supposed discovery being proclaimed to the eager public as another rich strike, or being claimed as another evidence of the illimitable wealth of this new found Dorado."

The extent of the celebrated Comstock silver vein at Virginia City is first considered. The portion known to be rich by actual examination, is said not to extend over six or eight hundred feet in length, and beyond this to appear to run out. A cross-cut or tunnel, run in two or three hundred feet south of the point at which the richest ore was raised, showed but faint indications of silver at the point where the supposed line of the vein was crossed. Another tunnel, by the California Company, was run in directly under the first, but thirty feet lower down, and the results at first were discouraging, but at last accounts the main vein had been struck, and rich ore obtained.

"Beyond these tunnels, both to the north and south, many others, some of them of far greater magnitude, besides several open cuts and perpendicular shafts, have been dug all on the supposed line of this lead, some being on a level with the original opening, some above and others below it, and yet no rich ore, scarce any thing resembling it, has been found in a single one of them. An incredible amount of labor has been expended in this species of prospecting, parties having been steadily at work in some of these tunnels for the last five months. And I am now speaking of operations in the Virginia District alone; being an area of some three or four miles in diameter about the rich mine. Beyond this, for miles in every direction, like explorations have been going on—and with the exceptions noted, with nearly like results. Of these explorations I will speak in another letter, closing, for the present, with the remark that it is not my purpose to deny the productiveness of these mines, or depreciate

their value as a discovery. The finding of a rich silver lode, though not yet traced to any great distance, is a fact of immense significance. These veins generally last long, pay steadily, and are not apt to be solitary. The finding of one gives good hope to expect the finding of another. That, when one discovery of this kind is made in a district another will follow, seems to have been accepted as a mining postulate; and I cannot help thinking it is upon this generally well founded assumption, rather than on the actual discoveries yet made, that the public confidence felt in these mines must be based. Of the rich ore, from the claims of various parties, there has now been raised over a hundred tons, averaging about two thousand dollars to the ton. Of this some fifty tons have found their way to San Francisco, which being culled, has, no doubt, paid a much higher figure. Besides this a large amount of poorer ore has been taken out, much of which will, no doubt, warrant being sent abroad for smelting, and the balance even will pay when suitable preparations shall have been made for its reduction on the spot. Apart from the silver ore large quantities of the quartz lead in which it is embedded, and which has to be removed with it, will yield from thirty dollars to two hundred dollars per ton of gold. The owners of the claims have been crushing this with arastras, making enough, in most cases, to pay all current expenses. From these statements it will be seen this silver lode, so far as it goes, is justly entitled to be called the richest in the world. That it is fully entitled to this reputation no one will deny; it is only against extending this reputation to the many other worthless leads puffed into notoriety that I desire to caution the public."

The gold Hill and Eagle Valley districts on the south are next described as follows:

"Contiguous to the Virginia district on the south, and next to it in importance, is the Gold Hill district, which though literally covered with immense ledges of auriferous quartz, has disclosed what can be properly termed silver ore at but one or two points. That this mineral is widely diffused over the entire district, however, is evident, many of the outer opening quartz leads being streaked with the ore, and much of the gold obtained being depreciated from thirty to seventy per cent. by its presence. At Crown Point, about two miles south of Virginia City, silver ore valued at $700 per ton has been found. Whether it exists in quantities is doubtful, not more than a few pounds of this description having been taken out at the time I visited it. The claim, consisting mostly of decomposed quartz, is being worked for gold, and, paying well, the owners not seeming disposed to engage in looking after a metal not so immediately remunerative.

"Three miles from Hastings and Woodworth's quartz mill, and on the east side of Carson river, being twelve miles south-east of Virginia City, silver ore, proved by assay to be worth $500 per ton,

has been discovered. It was found by some Mexicans prospecting in that neighborhood, and by them for a long time kept secret The ledge was afterwards mostly taken up parties engaged in crushing quartz, who, owing to their other engagements and the lateness of the season, have done nothing towards opening it, or securing the ore to be tested on an extended scale. Nothing therefore can be affirmed as to its abundauce, or the facility with which it can be raised. I do not know of any other ledge or locality in this district giving sufficient indications of silver to require mention.

"Coming south, we arrive in what is known as the Eagle Valley district—a section, until recently very little spoken of in connection with mining, as indeed it exhibits but few tokens of mineral wealth on its surface. There are, however, on both sides of Carson river, which runs through its eastern margin, a number of quartz ledges being prospected both for silver and gold; and although the appearance of the rock would seem to give very little encouragement to seek for the former, no small amount of labor has been expended on these claims—bestowed, as the parties interested assured me, on the strength of assays previously made. A company of Californians at work on the east side of the river, opposite Carson City, have excavated a large amount of rock, and are still going on, in hopes that the faint traces of silver met with will lead to something better."

Washoe Valley, which, according to the writer, was "at one time the center of attraction to the silver-seeking miner, and the field of some very flattering, but ill-founded expectations," comes next in review.

"The hills on the east side of the valley are an entire mass of quartz, a good deal of which looks favorable for gold. Owing to some slight signs of silver at one or two places, most of these ledges have been taken up, and a few of them prospected to a small extent. One only of the number is entitled to notice, and this less, perhaps, for what the rock actually assayed, than for what it was reported to have done. It is known as the Pickering Lead, that being the name of the person claiming to be the discoverer, and, as I have intimated, is worthy of mention only for the notoriety it has gained abroad through an alleged assay of the rock, giving as results $920 gold and $120 silver to the ton. This is now believed to have been a hoax; the ore sent to parties in this city for assay having probably been taken from the Comstock claim. This presumption receives strength from the fact that several subsequent trials made on ore taken from the Pickering Lead showed no silver, and very little gold. It would be useless to notice further the numerous rumors of silver ore having been discovered in this locality, since they all seem to have originated and resulted alike; leaving to this beautiful valley the honor of giving a name to the adjacent mines, without having thus far proved itself the possessor of mineral wealth.

"North of Washoe valley are yet two others—Pleasant and Steamboat valleys, having a mining chronology very like that already described. A reported discovery, an excitement, a rush, a speedy taking up of claims, a few days' labor to find them worthless, followed by a general abandonment. In Steamboat valley, however, some of the claims are being vigorously worked, but, as seemed to me, with very poor chance of success, since the substance obtained could neither be called silver or gold, except by a stretch of courtesy unknown to mineralogical etiquette.

"There is but one other locality calling for notice in connection with these silver explorations, and that some distance from the point where the first discoveries were made. A little more than a month ago, parties prospecting among the hills east of Carson river, and about twelve miles south of Genoa, came upon a quartz lead containing rock that is said to have yielded at the rate of $1,000 to the ton. I had a sample of this same rock assayed myself, which gave but $225 to the ton; but this was of the out-croppings, whereas the other came from ten or twelve feet below the surface, and I doubt not yielded as above stated. The character of the parties concerned precludes the idea of deception, though they might have been misled. This rock is said to exist in great abundance at the point where found, distant from Virginia City some forty miles."

The auriferous resources of the "Washoe district, are the subject of a separate communication, from which it appears, that the discovery of gold in that region, was made as early as the summer of 1852, by a party of immigrants. In prospecting an extensive bar or flat, at the mouth of what is now known as Gold Cañon, diggings were found yielding an ounce a day to the hand."

"In consequence a small number stopped, and having done well, the diggings being found to extend several miles up the ravine, there has been a considerable mining camp at that place ever since. Near the head of Carson Valley, fifteen miles above Genoa, gold was also found the same year not far from the emigrant trail. A number of tunnels were carried into the mountains at this place, and dirt sufficiently rich obtained to pay small wages. These operations, however, were soon abandoned and have never since been resumed—the only pay diggings found, until two years since, having been along the banks of Gold Cañon. About that period, coarse gold of low standard value was found on Six-mile Cañon, a ravine taking its rise on the eastern slope of the Sierra Nevada, near the head of Gold Cañon, and terminating on the plain six miles below the mouth of the latter, whence its name.

"The miners engaged in these diggings at that day were far from being an enterprising or an energetic race of men. Hence they took their time, worked slowly up these gulches, without going at once to

their heads, where the source of this drift gold would be supposed to exist. Thus years were consumed before they came upon the rich diggings and quartz ledges about Gold Hill, and the still more valuable silver lode at the head of Six-mile Cañon, the discovery of which was more the result of accident, than of persevering industry, or any well-planned project. The deposits of dust on Six-mile cañon, never sufficient to pay large wages, are now pretty well exhausted. At a few points very fair prospects can be obtained, yet they constitute insufficient inducements to undertake work, considering the high prices of provisions, and the scarcity of water. Along Gold Cañon for a distance of seven miles there are many bars, as well as a good portion of its banks, that would pay fair wages—say six to eight dollars a day—had they even enough water to work with a rocker, as is the case, for the greater part of the year, only at a few points. From the first of July till the fall of the winter rains, and often until the melting of the snow in the spring, there is no water running in Gold Cañon, and only enough furnished by springs along it to work a dozen or two rockers. Since the opening of tunnels, many of which have afforded a small stream of water, the supply has been slightly augmented; yet this has not inured to the benefit of the general miner, the water being mostly used in the arastras employed for crushing the rock taken out.

Along many of the ravines that made back from this cañon, as well as the ridges that separate them, are excellent surface diggings, and also valuable ledges of quartz, often so decomposed as to be easily crushed, or even washed to good advantage in a rocker, yet the entire absence of water and fuel render them of little avail. The quartz cannot be crushed in quantities without machinery, and careful observation has demonstrated the impossibility of ever bringing water to this locality through artificial channels. For two or three months in the spring, there will be plenty of water in all these gulches, and occasionally they are set running by the rains of winter. This, however, will not happen the present season, the storms thus far having been mostly snow, which now lies, as it will probably continue to do for several months, from one to two feet deep over this entire district. In a conversation I had with a hunter, he told me he encamped some years ago, in the month of January, on the spot now occupied by the hamlet of Gold Hill, and that the snow was over five feet deep. Most of it, however, went off in a few days, being followed by cold weather, producing an almost equally unfavorable condition for mining. About this place there is a great deal of quartz, easily obtained, that would pay well with ordinary facilities for crushing. Some fifteen or twenty arastras are at work here, and by selecting the best rock, are made to remunerate the owners. But it is expensive running even these, with hay costing $70 per ton, and barley ten to fifteen cents per pound. On Carson River, seven miles distant, two quartz mills have been erected, the one propelled by

horse, and the other by water power. They are capable of crushing three or four tons per day each. The rock, so far, has yielded about $40 to the ton. The cost of getting it out and hauling is $12, leaving not a large margin, all things considered, for profits to the owners.

The following is the most recent intelligence from the region, and is extracted from the statements of Mr. F. Hughes, to the *National Democrat* of California, in January:

He says that the thermometer has stood, at Virginatown and in the Washoe Valley, from sunset to sunrise, for the last two months, at from six to eighteen degrees below zero. The snow has been from three to four and a half feet deep. Flour is now selling at $20 a hundred, and is scarce.

Many persons at Virginiatown are living in excavations under the ground, like Diggers, or in the mouths of tunnels, for want of lumber to build houses.

The region immediately around Virginiatown is exceedingly rich. The Mexican Claim, in which Mr. John Atchison, of this place, has recently purchased a share (one-eighth), is very valuable. A specimen from this claim, shown us by Mr. Hughes, exhibits silver in abundance.

In Copper Cañon, nine miles east of Carson City, on Carson river, there are alternate veins of copper and silver of great richness. There is also in that vicinity a considerable amount of gold-bearing quartz.

The American Ravine, seven miles south of Virginiatown, is noted for its gold and silver veins.

The Grass valley silver lead at Virginiatown, contains large amounts of concentrated sulphate of iron and copper.

There are, within a quarter of a mile of Virginiatown, eight veins, which prospect silver largely; the veins bearing north and south.

Thirty miles east of Virginiatown, rich silver mines have been recently discovered, and are causing great excitement.

Ten or twelve miles east of Virginiatown, there are ledges now being prospected.

The Devil's Gate District, seven miles south of Virginiatown, is a celebrated locality. It contains ledges of gold and silver, ledges of silver and lead, which overlap each other, and form a complete network, the lines running north, south, east, and west.

East of Genoa, there is a vein known as the Dearborn Lead, whence occasionally good prospects are obtained.

In the Washoe region there is much gold-bearing quartz, but it all assays more or less silver.

At Steamboat Valley there are rich lead and silver mines. This valley is west of Virginiatown.

An excellent coal mine has recently been found at the west of the last named place.

Northeast of Carson Valley, fifteen or twenty miles from Genoa, a rich tin mine is reported.

Iron ore is very abundant throughout the whole country.

Sulphur, salt, and soda springs abound in various quarters of the Territory.

We omitted to mention that twenty-five miles south of Virginia-town, and east of Carson Valley, rich silver mines abound in what is known as Pine Nut Valley, a locality high up in the mountains. The discovery, which is recent, is producing great excitment.

Another remarkable feature of this marvellous country, is the great number of hot springs of pure soft water. Many families use the water for making tea and coffee, and for washing, without any fire.

New York Smelting Company.—We learn that a company with the foregoing title has been organized and incorporated under the laws of the State of New York to conduct the smelting works heretofore established at Staten Island. The capital is $50,000, divided into 1000 shares of $50 each. This company is prepared to purchase gold, silver, and lead ores for smelting, and are now engaged in smelting lead ores from New York, Pennsylvania, and N. Carolina, and silver ores from Central America and Washoe Valley, California.

Silver Vein in Mariposa Reported.—It is stated in the California papers, that a silver vein has recently been discovered in Mariposa, on Col. Fremont's estate, the ore from which is said to yield as much as the Washoe ore. A vein of silver ore is also reported to have been found in Calaveras County.

Silver from Mazatlan.—The steamer Santa Cruz brought to San Francisco, on the 19th Jan., $480,000 in silver from Mazatlan.

GOLD.

Reported Discovery of Gold Mines in Missouri.—The discovery of Gold and Platina, in Madison County, Missouri, has been reported in the local papers since last December, and has already been noticed in some of the foreign journals. Thus far, however, all the descriptions and notices which have met the eye of the Editor, have induced a doubt whether a particle of either of those metals has been found. A correspondent of the St. Louis *Democrat* who has examined the mines says the gold vein is twelve feet wide, and may be called a "hornblende trap," and "the gold is disseminated

in thin scales between the laminæ of the rock." He adds, "as the ore is new and the metals associated in it not yet fully understood, it must take some experimental analyzing to successfully separate the metals." [!] He also finds what is supposed to be "horn silver," and met a potter who having found some spots of white opaque enamel on his wares, "reasonably concludes that *tin* exists in veins in the rocks from which the clay is derived!"

According to Dr. Koch, of *Hydrarchos* notoriety, the deposit is from 40 to 60 feet wide, and yields two per cent. of gold and platina, or $107,252 worth to each ton!

Col. Fremont's Mines.—Col. FREMONT'S famous Mariposa grant is set down in the tax list as containing 47,370 acres, valued at $200,000; improvements, $8,000; personal property, $2,800. The total annual taxation on these valuations amounts to $4,457 30.—According to the Mariposa *Gazette:*

"Col. Fremont is actively engaged in the development of his Quartz Mines at Bear Valley and vicinity, with his characteristic energy. He has some two hundred "Celestials" employed in constructing roads to his mills on the river. A railway will soon be completed for conveying the rock to the river, and the cars for this purpose are now on their way from below."

The Stockton *Argus* says: "Orders have been received at the Globe Foundry in this city, for the casting of twenty-four amalgamators, sixteen of which are for the mammoth quartz mill recently erected by Col. Fremont. The pans weigh seven hundred pounds each, and are accompanied by machinery of peculiar mould, but of a recent and improved pattern, known as the Knox amalgamator. It is designed by Col. Fremont to give them a thorough test, and if found practicable, they will become universally used in the quartz mills in Bear Valley and in the other sections of the country where quartz mining is, to any considerable extent carried on. The Benton Mills, for which these amalgamators are designed, are situated at Ridley's Ferry, on the Merced river, and are capable of running about seventy stamps. A short distance above the mills, a dam thirty feet in height has been placed across the river, over which the water falls in a broad sheet, producing a roaring noise that may be heard for miles. On the south side of the river, at an elevation of 1,480 feet, are the celebrated Josephine and Pine Tree veins, from whence the quartz is taken for these mills."

Exports of Gold from San Francisco.—Our San Francisco files by the *Baltic* contain the full returns of the Gold trade and general commerce of that port for 1859, of which an abstract was furnished

some days since through our overland despatches. We copy as follows:

Export of Gold to	1857.	1858.	1859.
New York	$35,287,778	$35,578,236	$39,831,937 32
England	9,347,748	9,265,739	3,910,840 37
New Orleans	244,000	313,000	314,500 00
Panama	410,929	299,265	279,949 28
China	2,993,264	1,916,007	3,100,755 68
Sandwich Islands	86,803	98,672	142,190 00
Manilla	278,900	49,975	26,200 00
Australia	32,000	631	——
Mexico	41,500	14,500	——
Chili	33,479	11,500	——
Society Islands	——	2,000	——
Japan	——	——	34,000 00
Other countries	220,296	500	——
Total	$48,976,696	$47,548,25	$47,740,462 65

The imports of treasure were:

From Mexico	$2,431,021 27	From Australia	$4,885 00
From Chili	14,852 00	From Sandwich Is.	28,785 96

Total for 1859	$2,478,544 23
Total for 1858	2,323,501, 49

—*Times.*

Deliveries of California Gold at New York:

1859. From Jan. 1.		1858. From Jan. 1.	
January 12	$1,384,664	January 13	$1,607,440
January 28	1,210,713	January 27	1,555,279
February 12	1,319,924	February 13	1,348,507
February 27	1,287,967	February 27	1,840,429
March 13	920,177	March 16	1,279,134
March 29	1,032,314	March 26	1,403,940
April 13	1,404,029	April 13	1,352,912
April 25	1,723,352	April 27	1,486,565
May 14	1,483,426	May 13	1,615,551
May 26	1,938,699	May 29	1,575,991
June 13	1,529,595	June 12	1,446,175
June 26	2,041,237	June 27	1,799,502
July 12	1,741,879	July 14	1,401,713
July 27	2,145,000	July 27	1,603,817
August 11	1,863,691	August 12	1,527,286
August 27	2,126,333	August 27	1,434,674
September 12	2,046,002	September 11	1,696,639
September 26	2,043,363	September 28	1,570,000
October 17	1,883,670	October 15	1,322,005
October 25	1,871,550	October 28	1,472,979
November 10	1,568,107	November 12	1,672,676
November 28	1,721,343	November 28	1,816,532
December 12	1,865,429	December 13	1,643,202
December 24	1,408,234	December 30	1,494,379
Total, 1859	$39,560,698	Total, 1858.	$36,766,820

—*Times.*

MISCELLANEOUS.

Washoe Silver Mines.—Since the notices of the Washoe mines were in type the following letter, received by the Baltic, appeared in the *New York Times*, and is from the correspondent, "Podgers," upon whose statements the Editor of the Mining Magazine relies.

The Washoe Silver Mines, as they are called, continue to create as great an excitement as ever, although covered with snow at the present moment some four or five feet deep. * * * * * They were first discovered by Mr. PATRICK McLAUGHLIN, an "honest miner," who was working for gold in a gulch or ravine, and where he was making $100 a day to the hand. As they followed up the gulch it paid even better, until on arriving at a certain point it gave out altogether, and they struck a vein of what they at first supposed to be coal, but observing that it was very heavy they concluded it must be valuable, and at once staked off 1,500 feet as their claim. They sent one of their number to San Francisco with some of the black ore to ascertain its value. It was given to a Mr. KILLALEY, an old Mexican miner, to assay. KILLALEY took the ore home and assayed it—the result was so astounding that the old man got terribly excited. He rushed over to communicate the fact to Maj. ALLEN, but not seeing him, returned to the "Tehama House," where he lived, and it was observed that he was very much excited; however, he retired as usual, but the next morning poor KILLALEY was found dead in his bed. He had long been in bad health, and the excitement killed him. The fact that the ore was valuable finally leaked out, and those in the secret set out for the mine, and bought in—generally at the rate of about $10 a foot—and it has been sold and resold, until at the present moment not one of the original owners has a dollar's interest in it. The "lead" was found to continue, and some hundreds of feet additional were taken up, and it now stands thus: The original Company, under the title of the Ophir Mining Company, own 1,400 running feet of the vein; next comes the Mexican claim, as it is called, 150 feet; then 150 feet, belonging to the Central Mining Company; then the California Company, 150 feet. The Ophir Company set to work and opened the vein by sinking a shaft 30 feet deep, and running a gallery 40 feet, from which they took 45 tons clear ore, which is now being smelted in this city, giving an average of $3,600 per ton; besides which, upwards of 800 tons of quartz rock was thrown out, worth $300 per ton of gold, giving $256,000 and odd, as the result of five weeks' labor;—besides this, the Central Company took out nearly 20 tons, and the Mexican has taken out as much more. The Ophir Company's vein is well defined, 10 inches thick, of dense solid ore, and recently the shaft has been

sunk 20 feet lower, and no diminution found of the width of the vein or quality of the ore. In the Mexican claim it is found even wider and richer, and it may extend down through to China for what we know. There seems to be but two kinds of ore—a crumbling, black, dull, and a denser and more sparkling kind—showing sulphurets. I sent a piece of each to New York to be assayed, which was done by H. Solomon & Co., and I have the result before me; the crumbling ore gives $3,770, and the sparkling ore $9,064 66 to the ton! to which result that well-known and highly respectable firm set their hands and seals. The shares commenced changing hands in August, at the rate of about $70 per foot; in September at $100, or $23,300 for a sixth. It sold last week at $500 per foot, or $116,500 for a sixth, and is still going up, up; 25 feet of the Mexican claim sold for $30,000, and $100,000 was offered and refused for the other 125 feet.

In addition to these claims, there are parallel ledges taken up just before the snow fell, which, from hasty and imperfect prospecting, are judged to be equally rich. These veins are so distinctly marked that there is no difficulty in tracing them several hundred feet, and there is no doubt that other leads will be found equal to the first, or Comstock lead, as it is called. When the snow melts the work will commence, and the rush will nearly equal the Frazer River excitement. There is no estimating the amount of ore that will be taken out. It will be immense; $500 a foot seems a high price to pay for a mining claim, but when we look at it a moment, it is cheap. The shaft in the Ophir claim is now 50 feet deep; the vein 10 inches to 14 thick—giving 300 and odd pounds to the running foot, so that one running foot 50 feet deep gives 15,000 pounds or 7½ tons, which—at the lowest result yet given, $3,000 to the ton—gives $22,500 to the foot, supposing the vein to be 50 feet deep, which we *know* it is, not counting the quartz rock, which gives $300 to the ton for 15 *feet each side of the vein of silver ore.* The vein has been traced and prospected the whole 1,400 feet, and is good. The number of shares for sale now is limited, and doubtless will soon be absorbed. The Ophir Company has been regularly organized, having a Board of Directors or Trustees, composed of men of character and of ability, and the mine will be worked on a large scale in the Spring, and a large quantity of ore taken out. It is probable that it will be converted into a Joint Stock Company in the Spring. The following gentlemen compose the officers of the Company at present; Henry Atchinson, Superintendent; Major Robert Allen, U.S.A., H. H. Raymond, James Woodworth, Esq., George Hearst, Louis A. Garnet, —— Meredith, Esq., Directors; R. S. Ogden, Treasurer. Several other Companies are being formed to work the adjoining veins.

THE

MINING MAGAZINE

AND JOURNAL OF

GEOLOGY,

MINERALOGY, METALLURGY, CHEMISTRY, AND THE ARTS IN THEIR APPLICATIONS TO MINING AND WORKING USEFUL ORES AND METALS.

APRIL TO JULY, 1860.

ART. I.—THE WHEATLEY SILVER LEAD MINES.

BY THE EDITOR.

THE Wheatley mines are justly celebrated among mineralogists as the source from which the principal mineralogical cabinets of the world have been enriched with the choicest and most beautiful crystallizations of the ores of lead, and other minerals. They are not less well known among the practical miners and metallurgists of the United States for their large production of silver-bearing lead, and the fair prospect they have given of a permanent yield of this valuable ore.

Having recently visited these mines, some interesting facts regarding their past and present condition were obtained and are here presented, together with some observations upon the ores and their distribution in the vein. As the mines are now full of water, the investigations were necessarily confined to the surface, and to the very full and instructive suites of minerals which have been reserved to illustrate and represent the mine. To Captain Cockin, who has been familliar with the mine from the first opening, and to Mr. Chas. M. Wheatley I am indebted for most of the facts here stated, which did not come under my own observation. The very complete and accurately drawn maps and sections of the mine were also of great service in forming a just view of the lode and its character.

The Wheatley vein is one of a group of metal-bearing lodes extending in nearly parallel lines in a general northeast and southwest direction through a portion of Montgomery and Chester counties, Pa. It is about 27 miles from Philadelphia, and is near Phoenixville, on the Reading railroad. At this place, the red sandstone strata of secondary age rest upon the upturned edges of gneissic rocks, and the ore-bearing vein occurs near the line of junction of the formations, and cuts both; the lower part of the vein being in gneiss, and a portion above in the red sandstone. Professor Henry D. Rogers, the State geologist of Pennsylvania, who has examined and ably described this vein, regards it as undoubtedly injected, or a true fissure vein and as originating at, or after the close of the secondary period, perhaps at the time of the intrusion of the trap ranges which intercept the same strata in their range from the Hudson to the Potomac, and in the valley of the Connecticut.* Although the trap and the vein may be contemporaneous, there is no direct, or established association, and the vein belongs to the gneissic rocks, rather than to the sandstones and shales of the secondary.

CHARACTER OF THE VEIN AND EXTENT OF MINING.

This vein was discovered and opened in the spring of 1851, by Mr. Charles M. Wheatley, and work was commenced with a small pumping engine. In September, 1854, the engine shaft had been sunk fifty fathoms from the surface, or three hundred feet. An adit-level had also been driven on the course of the lode 1325 feet, draining the shaft to a depth of sixty feet. The ten fathom level was driven 1250 feet; the thirty fathom level 477 feet, and the forty fathom level 107 feet. These, including the branches on the lode, made the whole number of feet driven at that time, over 4000. These figures show substantially the present extent of the Wheatley mine proper, for the work was suspended soon after that date, and has not since been resumed. The Longitudinal Section which is appended will show by a glance, the depth and extent of the principal workings, and the amount of ground that has been stoped. This, however, is but a partial section, as the vein has been followed and worked upon at different points on either side of the main or engine shaft, and not represented in the section; indeed, two mines, bearing distinct names—the *Brookdale*, and the *Phoenix mine*,—have been opened and worked on the prolonga-

* See Report of Prof. H. D. Rogers, on the Wheatley mines. Philadelphia, 1853.

tion of the same vein to the west, which has been traced, in all, over 3000 feet. The relative positions of these mines upon the vein, and the extent of the workings at each, was shown in a Report and Statement published in 1855, from which it appears that the distance between the Wheatley and the Brookdale shafts is 2076 feet, and between the Brookdale and the Phoenix, about 1380.

At the Brookdale mine, the engine shaft is 192 feet below the surface, and 36 feet below the 26 fathom level. At the Phœnix, the engine shaft is sunk on the underlay of the vein ninety feet, and at the bottom a level has been driven about 200 feet each way. It is thus seen that the greatest amount of work has been expended at the Wheatly mine proper.

The vein makes but little show upon the surface, and for the most part lies below cultivated soil. It is exposed in the bed of a little rivulet near the Brookdale mine, and consists of a quartzose gangue, crystalline and cavernous, which, on being broken out, is found to contain masses of galena. The character of this outcrop clearly indicates that it is a fissure vein, and not of segregation or contact merely, and these indications are sustained by the character of the vein and walls below. The width varies from one to two and three feet; at one point it was four feet wide, and three feet of it was solid galena. This rich mass of ore extended with a decreasing thickness from the 20 fathom to the 30 fathom level and below, where the whole vein was about two feet thick. In the Brookdale mine, the vein, left standing in the west end of the 14 fathom level, was two and a half feet thick, and composed chiefly of quartz and gossan.

The dip of the lode is about twenty inches in a fathom, or about seventy-five degrees, and is toward the south. The engine shaft is sunk vertically, so as to intersect the vein near the 50 fathom level, between which and the surface the lode is reached by cross-cuts, at intervals of ten fathoms, or about sixty feet.

The main lode has several branches which yield good ore. They are found to diverge from the main vein, and either thin out in the wall-rock or again enter the vein beyond. In this case a portion of the wall-rock may be said to be enclosed in the vein, forming what is called a *horse*, among miners. Such parts of the wall-rock or the horses in this mine are generally traversed by small veins or strings of ore. A branch at the bottom of the 30 fathom level, where the ore is ten inches thick, remains unworked. The main vein opposite is about two feet thick.

THE ORE AND MINERALS

The chief ore-product of this vein is an argentiferous galena, which is accompanied by an abundance of phosphate of lead, —pyromorphite—also argentiferous.

It has been observed by Mr. Wheatley and Captain Cockin, and is noted by Professor Rogers, that where the vein is confined to the gneiss the ores of lead predominate; but when in the sandstone or red shales, the ores of copper are most abundant. Zinc blende is a large constituent of the vein in both formations.

In 1851, eleven tons of ore were raised, but at the time of suspension of mining in 1854, the whole production had reached 1800 tons, 1000 tons of which, averaging 60 per cent. of lead, had been raised during the last year. The galena ores yield from 70 to 80 per cent. of lead and from 15 to 120 ounces of silver to the ton, or from 26 to 30 ounces on an average. The phosphate ore yields about five ounces of silver to the ton, and the gossans on the back of the lode are also found to contain a notable portion of silver.

The galena occurs chiefly upon the hanging wall, and is both crystalline and massive, often with a fibrous or veined structure and fine grain. The phosphate presents almost all shades of green, from yellowish green to a dark olive green, and is commonly well crystallized in hexagonal prisms, sometimes closely aggregated in large heavy bunches, and again spread in distinct crystals over broad surfaces of quartz or gossan. It has lately been found in stalactitic crusts enveloping large crystals of galena, which are much corroded below the crust, as if dissolved or eaten away by acids, while the crusts of phosphate appear to have been derived from the decomposition. It is most probable that the pyromorphite is a secondary ore formed by the change in the ore in the upper portions of the lode, to which atmospheric influences penetrate; yet it is difficult to account for the source of such a large quantity of phosphoric acid, when it has not been recognized in the minerals of the unchanged deeper parts of the vein. It is found also that the phosphate is most abundant near the surface, where the galena is nearly replaced by it and other salts of lead. It exists in small quantity as low as 38 fathoms below the surface, but below this the minerals are chiefly galena, blende, copper and iron pyrites, calcite, carbonate of lime, fluor, spar and quartz.

At this time a considerable quantity of phosphate ore is being taken from the back of the vein near the surface. Over

six tons of this ore, washed and dressed to about 60 per cent. of lead, and worth about forty dollars a ton, were shipped during my visit.

The crystals of sulphate of lead, *anglesite*, from this mine, are finer than from any other known locality, and are deservedly held in the highest esteem by mineralogists for cabinet specimens. The finest crystals are colorless and transparent, like rock crystal, and have very perfect and brilliantly polished planes. These are commonly found in cavities or nest-like spaces in the galena, and appear to great advantage in contrast with the dark and ochre-lined walls. One of the crystals found in this mine was five and a half inches long and an inch and a half thick, with perfect terminations. They are most abundant in the deeper parts of the mine.

Carbonate of lead or *cerusite* also occurs in beautiful crystallizations in cavities, like the sulphate, but chiefly in the more porous and friable portions of the ore or gossan. They are also found coating galena and other minerals of the vein.

Molybdate of lead—*wulfenite*—is another very intersting species, which is found chiefly in the ore from whim shaft No. 2. It is in small bright red, and yellow crystals, frequently disposed upon broad surfaces of green phosphate. When this mineral was first detected in 1851, only two or three very minute red crystals were obtained, and were mistaken for chromate of lead, which they much resembled. Dr. Wetherill of Philadelphia examined the mineral after it was obtained in greater abundance, and did not find any chromic acid. Dr. J. Lawrence Smith, in his interesting and very full descriptions of the minerals of this mine,* refers the red color to the presence of vanadic acid.

The most interesting mineral species hitherto obtained from the vein are enumerated in the following list:

Galena, Blende, Iron and Copper Pyrites, Native Silver, Pyromorphite, Anglesite, Cerusite, Wulfenite, Vanadate of Lead, Mimetene, Calamine, Malachite, Azurite, Fluor Spar, Calc Spar, Heavy Spar, Sulphur, Brown Hematite, Dolomite, and Quartz Crystals.

A very fine series of these minerals, together with suites of the ore as they come from the mines, and as dressed for market, were sent to the Mineralogical Department of the New York Crystal Palace exhibition, and attracted much attention from scientific and practical men. Professor B. Silliman, Jr., in his report upon this department of the Exhibition, observes: "We speak understandingly and without exaggeration when we say,

* American Journal of Science, [2] xx, 246.

that the sulphate and molybdochromates of lead in Mr. Wheatley's collection are the most magnificent metallic salts ever obtained in lead mining, and unequaled by anything we have seen in the cabinets of Europe." The report of the Jury of Class 1 says: "The value and importance of the objects exhibited from the Wheatley mines, the superior excellence of the specimens and prepared materials, the fullness and exactness of the plans of the mining operations, drawings of machinery, &c., together with the fact that this exhibition is the result of mining operations due entirely to the labor and skill of the exhibitor, and constitute a positive addition to our previous knowledge of the resources of the country, claim from the Jury the highest award, namely, the silver medal." The collection was also favorably noticed by Professor Wilson, in his Report to the English Government. The occurrence of so many interesting minerals at this mine is not only pleasing to mineralogists, but encouraging to the miner; the practical inference being, that the lode must be very rich to produce the salts of lead in such abundance and variety.

DISTRIBUTION OF THE ORE IN THE VEIN.

The ore in the mine is not found in nearly equal quantities throughout the course of the vein or fissure, spread, as is commonly supposed, with an approximation to uniformity along or between the walls, with perhaps here and there a poor place irregularly disposed. On the contrary, an examination of the ore-ground, and especially of the accurate working sections, exhibiting the extent and position of the ground which has been stoped out, at once shows the inaccuracy of such a view, and the fact that the part of the lode in the vicinity of the engine shaft is the richest which has yet been opened. The outcrops and surface indications were also most favorable in that vicinity. The mining operations have sufficiently developed the character of the vein to show beyond a doubt that the ore is distributed in elongated patches or *shoots* along the vein, having a *vertical rather than horizontal extension*, and lying *parallel with each other*. They are also found to dip, not only with the vein, but obliquely upon it, plunging towards the west at an angle of 45°. These shoots vary in size from a few inches to four or five feet in their transverse section, while their length from above downwards is much greater. Thus, in driving a gallery westward on the lode, these shoots were cut across transversely in succession, the ground between them not being devoid of ore, but, though poor compared with the

body of the shoots, was, in general, rich enough to pay the expenses of driving.

The distribution of the minerals in the shoots is also an interesting point. Captain Cockin has observed that in passing through a shoot, *blende* is most abundant on each side, while the central portion is occupied by galena and lead salts.

The ore shoots are arranged in groups or masses, being, for example, most abundant, as far as yet known, at the Wheatley mine. The body of ore which has there been excavated upon may be regarded as a group of ore shoots conforming in all its characters to those of the individual shoots of ore composing it, extending downwards like them at an angle of forty-five degrees, and to a great depth.

If we consider this to be the type or general character of the ore deposit, we may look for other and parallel bodies of ore at other points along the vein, either outcroping at the surface or terminating below it. Such shoots would be cut underground by extending prospecting galleries along the course of the vein.

Such an arrangement or distribution of ore is not peculiar to this locality or vein, but it is observable in many others, especially in the gold veins of the southern States, and in California. I recognize in it the result of a general law governing the filling of mineral veins, and have accumulated many interesting facts and observations bearing upon and illustrating the subject, which cannot be fully presented here.

It is obvious that these general conclusions respecting the position and extent of the ore in the Wheatley vein have an important practical bearing upon the mining operations. The direction and extent of future workings should be modified in conformity to them. Thus, the attention should first be directed to the extension of the mine along the main body of ore, so as to follow it in depth, and avoid the extension of levels beyond the bounds of the paying ground, except for the purpose of exploration. Such prospecting or exploring galleries may be located at the most convenient and encouraging points, as the mining progresses.

The main engine shaft is favorably located, but according to the above view of the distribution of the ore, would have been better placed if farther west, so as to keep upon the shoot of ore to a greater depth. It should be sunk twenty or thirty fathoms deeper, and the galleries extended westwardly in the direction of the main body of ore. On reaching the vein with the shaft, which will probably be at the fifty fathom level, it may be found best to change the direction of the shaft from the vertical, so as to follow the dip or inclination of the ore. If,

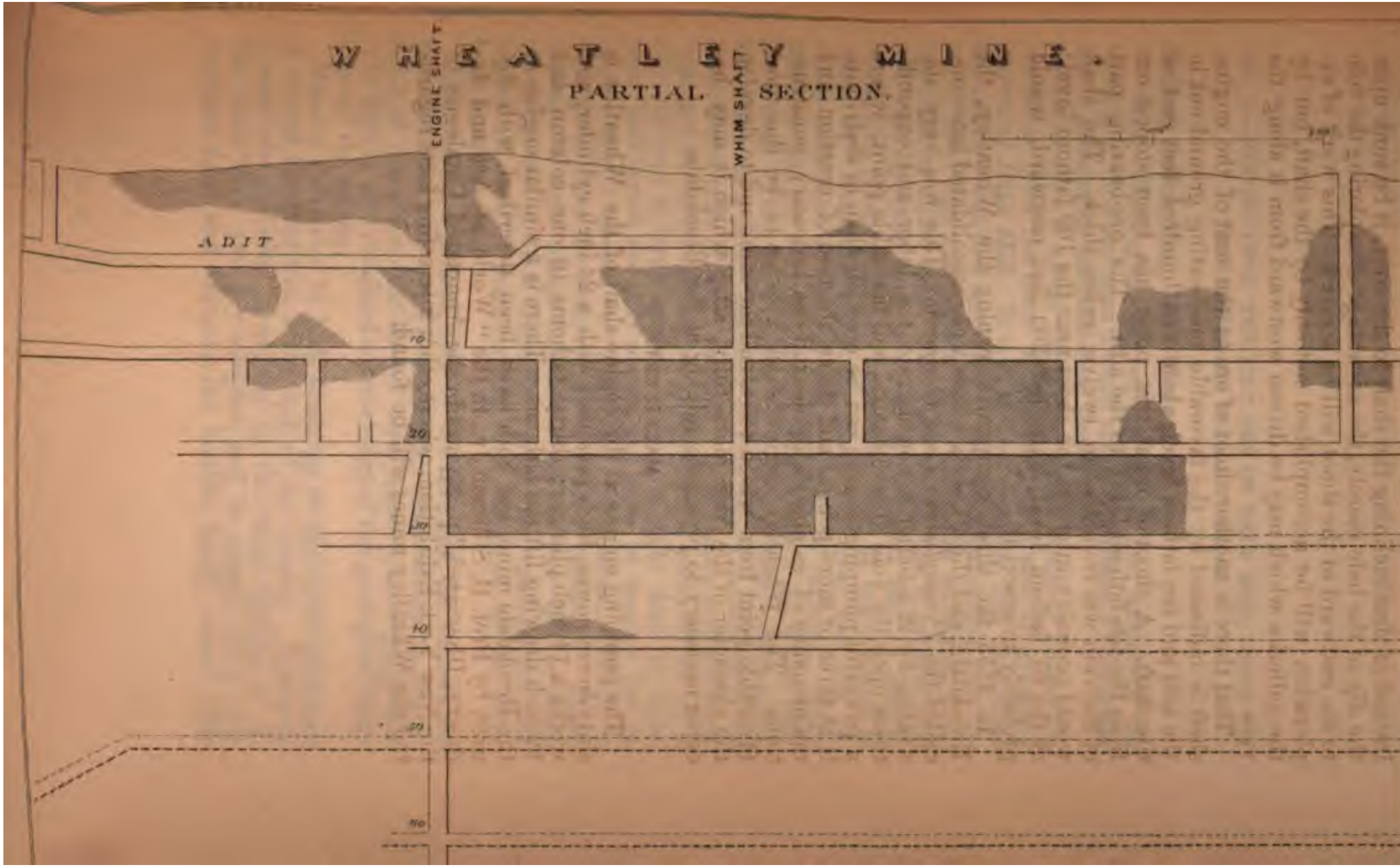
instead of thus inclining the shaft to the west, it be sunk upon the *dip* of the lode merely, the advantage of exploring the vein to the eastward of the shoot will be secured. This work of exploration will be accomplished not only by the shaft, but by the galleries which may be driven westward from it along the vein.

That there is another shoot of ore to the east of the engine shaft is indicated by the favorable ore-bearing ground cut in the adit and ten-fathom level, about five hundred feet east of the shaft. A shoot of ore at that point has been stoped out from the ten fathom level to the adit. The ore-bearing part of the vein was from nine to twelve inches thick. The shaft would probably intersect the shoot near the 100 fathom level; or the 60 fathom level, extended 200 feet eastward, would probably intersect it.

In 1855 the three companies owning the Wheatley, the Brookdale, and the Phoenix mines were consolidated into one, called the *Pennsylvania Lead Company.* This was very desirable, for it is better to concentrate the labor and expenditures upon the vein at one central and favorable point, where a powerful pumping engine can be erected, than to distribute it at three or more points, and have the cost of erection and maintenance of as many engines and the necessary constructions. The Wheatley engine shaft appears to be the most favorable point from which to extend the mine and to develop the character of the vein more fully, after which it may become necessary to prosecute mining at the Brookdale.

MACHINERY.

The pumping engine at the engine shaft of the Wheatley is sixty-horse power, high pressure, with a 24-inch cylinder, and works a 14-inch plunger; thirty fathoms in one column and 12-inch drawing lift ten fathoms. There is a similar engine at the Brookdale mine, and both have been described, with figures, by Prof. B. Silliman Jr., in the "World of Art and Industry, Illustrated," p. 57, and in the Annotated Catalogue of the New York Exhibition, where other interesting facts regarding the Wheatley mines will be found.



WHEATLEY MINE.
PARTIAL SECTION.
ENGINE SHAFT
WHIM SHAFT
ADIT
10
20
30
40
50

ART. II.—REPORT UPON THE ZINC ORE OF BALD HILL, UNION CO. TENNESSEE.—By WILLIAM P. BLAKE.

SAMUEL SMITH, ESQ., NEW YORK:

SIR:—Having at your request visited and examined the locality of Zinc ore upon Powell river, Tennessee, I take pleasure in presenting the following Report:

This locality is about thirty-five miles north of Knoxville, ten miles from the town of Maynardsville, and is generally known as *Bald Hill*. It is so known from the fact that when the country was first settled, a broad space extending over the top of the ridge was without trees, while the unbroken forest extended on either side. This bare space has a general east and west direction, and is about a thousand feet in length. Shafts and prospecting pits have been dug in many places in search of "mineral," which the absence of trees, and the peculiar dark color of the soil was supposed to indicate. Many of these pits are very old, and it is not known by whom they were dug. They have caved in, and are nearly obliterated, but there is a large quantity of zinc ore—the carbonate—in the soil and piles of earth around. In the more modern openings, and at various points upon this barren area, carbonate of zinc outcrops in large masses. It has a light drab or fawn color, and occurs not only porous and open in texture, but in large compact masses, very solid and even-grained, difficult to distinguish from the compact fawn-colored limestone. These outcrops in some places formerly stood up two feet or more above the soil in thick slabs, like curbstones, but these are now broken off, most of them having been removed to the river bank for shipment.

After taking a general view of the hill, and the various exposures of the zinc ore, I extended my observations to the locality of zinc ore on the Russell farm, about three-eighths of a mile distant, and obtained a knowledge of the geological character of the region.

Massive limestone, in beds attaining an aggregate thickness of several hundred feet, is the rock of the country. It is well exposed along Powell river, and in the valley leading to it. The lower beds are very compact, and in places afford very beautiful dove and fawn-colored marble, deeply veined with

brown. The prevailing dip of the strata is to the northeast, (N. 60°—70° east in one place,) at an angle of 15° to 20°. The upper members of this series of limestone strata present a black and very rough surface, produced by unequal weathering. When struck or broken, a powerful fetid odor is emitted, and in places the rock is sandy. It is in this rock that we find the zinc ore on the Russell farm.

On returning to Bald Hill another opening in which zinc ore is found was pointed out to me, about three hundred yards further west, near the road and blacksmith shop. This opening is much lower than those on Bald Hill. Here, also, the forest trees did not grow for a space several rods in length.

THE VEINS—THEIR CHARACTER AND EXTENT.

It is evident at all of the openings that the zinc ore occurs in veins cutting across the strata and not in beds lying between or parallel with them, though it is possible that such beds will be found when deep excavations are made. These veins are nearly vertical, and their direction upon Bald Hill appears to be about east and west, or 95° east of north. It is evident also that there are numerous parallel veins of different widths separated by limestone. They appear to be very similar to the vertical crevices or gash veins of the Mississippi lead region; the ore being without any gangue or veinstone, and completely filling the space between the walls.

The extent of these veins in length and breadth upon or near the surface, is indicated in a general way by the absence of forest trees, and by the peculiar blackness of the soil. The outcrops, however, and the developments made by the shafts show with certainty that the ore is spread over a great breadth, while at several places the indications are enough to warrant the expectation of finding the ore at almost any point within the width of from sixty to eighty feet. As already stated, the ore is probably in a great number of separate veins, lying parallel, and divided by thin layers or seams of limestone. Extended operations in mining or excavating on the surface are required to develop the true character and extent of the veins throughout. For the general position and relations of the several outcrops and exploring shafts, reference may be made to the accompanying Sketch Map of the hill.

In the lower opening—the open cut at the east end of the hill—the breadth of one of the veins of ore appears to be about five feet, and I here dug out some very handsome specimens of zinc ore of the best quality.

The principal shaft upon the property, is that dug by Mr. Vint, sixty years ago, thirty feet deep, which was cleared out by Messrs. Hammond in 1835–6 to the depth of 55 feet. This was done in search of lead ore, of which a considerable quantity was obtained and smelted in a rude furnace at the river.

The ore was also believed to be rich in silver. A tunnel ten or twelve feet in length is said to have been driven on the course of the lead ore from the bottom of this shaft. Zinc ore was found in quantity from the top to the bottom of the shaft, and the earth which was thrown out is charged with fragments of calamine. Two or three old shafts on the same line, all of which are now caved in, are believed to have been made in search of lead ore. In the prolongation of this line of shafts, outcrops of limestone are found, but beyond, on the top of the hill, and in nearly the same line, a cross-cut of a few feet in depth exposes a vertical bar of calamine with a thin layer of lead ore on one side. Wherever the lead ore was observed at the openings it was in a thin layer an inch or less in thickness. A shaft sunk by Major Hurst, at the lower end of the open cut, is thirty-seven feet in depth, and exposed a considerable quantity of zinc ore, though limestone, only, is found at the bottom. This is probably at one side of the main bed of zinc. The vertical section of the hill, which is appended, is designed to show what is believed to be the general character of the zinc deposits at that locality.

In judging of the probable amount of ore, we should remember that the openings thus far have not been made with direct reference to the exhibition of the zinc ore, yet enough is seen to warrant preparations for mining on a large scale, or the establishment of works for the manufacture of the metal or its oxyd. We should also take into account the fact that calamine exists at the Hammond and Steiner shaft, a hundred feet or more below Bald Hill. This shaft was sunk by Hammond and Steiner for lead ore, a layer of which is still visible in the side of the shaft, together with a thick mass of calamine. It is most probable that this vein is a continuation of the Bald Hill group of veins, and that the ore will be found to be continuous between the two places. It does not show, however, upon the surface, but may be found by sinking prospecting pits, especially in the little valley or depression between the two hills. This evidence of the great extension of the veins is important and taken in connection with the fact that the ore occurs at another point—Russel's farm—in the upper beds of

the series it appears almost certain that the zinc veins have an extended vertical range through the limestone strata, and that the ore at Bald Hill extends downwards as low as that in the Hammond and Steiner shaft at least. On this point—as to the quantity of ore—there need be no hesitation. A pile of over twenty tons, by estimate, now lies on the river-bank for shipment, which was collected from the surface, and in the open cut in a short time. Many of the masses weigh several hundred pounds, and are nearly two feet in length and breadth.

QUALITY OF THE ORE.

The ore on the river bank, collected from different points, afforded me an excellent opportunity for ascertaining its general character.

It is the best quality of *Smithsonite*, "Calamine," or Carbonate of Zinc, which, next to the oxyd, is the purest and best ore of zinc to work for the metal, or for the manufacture of white oxyd for paint. When pure, it has the following composition in 100 parts:

Carbonic acid, 35.19,
Oxyd of zinc, 64.81.

It is named in honor of Smithson, the founder of the Smithsonion Institution, who early examined this species, and analyzed samples from Somersetshire and Derbyshire, England, finding a composition nearly agreeing with the above. The analyses of samples from various European localities show a variation from 74 to 96 per cent. of pure carbonate present, the impurities consisting of clay and other carbonates.

The Bald Hill ore is remarkably pure, and when cleansed from adhering clay and oxyd of iron will probably average from 80 to 90 per cent. of carbonate, or from 64 to 72 per cent. of metal.

The ore on the bank will probably yield over 80 per cent. carbonate. Some of the ore bears but little resemblance to the usual form of the carbonate, being very compact and massive, and like the limestone or marble in fracture or color. Some samples taken from such blocks, and from outcrops of similar ore on the hill were proved to consist almost entirely of carbonate of zinc, when examined before the blowpipe. There appears to be a large amount of ore of this quality, and it would generally be mistaken for limestone, unless lifted in masses, when its great weight would at once indicate its metalliferous character.

The open, cavernous specimens are formed of thin crusts or layers of the carbonate: the surfaces of which, are finely mamillary and occasionally sub-crystalline; they are white, bluish-white, and yellowish in color; translucent, and sometimes opaque. They usually cover or inclose portions of ochre or peroxyd of iron, and are formed also upon masses of galena, which becomes visible on breaking the specimen.

The ore, as it comes from the mine, will probably be more or less charged in the cavities with ochery earth and oxyd of iron, the greater part of which may be removed by washing or long exposure to the weather. The ore on the river bank is nearly free from such impurities, while the masses of similar ore that I broke out from the vein were not.

The specific gravity of pure Smithsonite varies from 4. to 4.45, being over four times as heavy as an equal bulk of water. The lead ore, galena, will be an important product when the mine is extensively worked for the zinc ore, from which the lead can be readily separated by hand-sorting, so that it will not interfere with the successful manufacture of spelter or the white oxyd of zinc for paint.

There are no indications of the existence of blende—the sulphuret of zinc—at the locality, but it will doubtless be found when the mine is deeply worked. We may regard the carbonate as the result of the decomposition of blende, and this chemical change may account for the absence of trees along the vein. The decomposition has probably reached a great depth, as the open spaces of the limestone and vein allow the water to drain off and give access to the air, by which, with the moisture, the change is effected. Zinc-blende, with galena, occurs at a locality several miles distant, in a thin vein in limestone, near or at the water-level of the river, where it is probably kept wet the greater part of the time.

It is interesting to observe that the ores used by the celebrated establishments in Belgium—the *Nouvelle* and the *Vieille Montagne*—are similar to those of Bald-Hill, and further, that veins or bunches of galena are found in connection with them, and that the localities were formerly worked for the lead alone. The formation in which the ores occur, are dolomitic Silurian limestones, and Burat, the eminent French Mining Engineer, has suggested that the ore was deposited from below, along the walls of ancient metalliferous solfataras.* According to the

---

* *Etudes sur les gites calaminaires et sur l' industrie du Zinc en Belgique, Par Amédée Burat, Paris*, 1846.

horizontal galleries which may be run in at the foot of the hill or slope on which the shaft is dug. The vertical extension of the ore to the top of the hill, above the shaft, has not yet been shown by openings.

Whatever the system or plan of mining may be, the ground will be found comparatively soft and easy to break. The ore itself may be broken down with pick and bar without the use of powder.

As regards transportation, the ore is well situated, being about a quarter of a mile from the bank of Powell River. This is a large stream, which empties into the Clinch River, a few miles below, and this last into the Tennessee, by which there is water communication to Chattanooga, Tennessee, Huntsville, Alabama, and, by way of the Mississippi, to New Orleans. Powell River is navigable for flat-boats, in which the ore must be shipped, but it is necessary to take advantage of the annual floods or freshets which occur frequently during the winter. Boats are frequently freighted with lumber from points above the zinc mine. The boats should not carry over eighty tons, and they can be built for about a dollar a foot, or eighty dollars for one that would carry eighty tons. Such boats, it is said, would bring their cost or more at the points where the ore would be delivered. From the mine to the river-side there is a good road, with a descending grade, and the distance is about a quarter of a mile. At Chattanooga the ore would meet the railroad and coal, and could either be taken direct to Charleston or Savannah by rail or be manufactured there. If it were thought desirable to establish works at the mine, an abundance of wood or charcoal can be obtained at small cost, and good bituminous mineral coal is within twenty miles of the mine.

The Mossy Creek zinc locality, I am informed, is two and a half miles from the Holston River, so that the cost of delivering ore from that locality would be much greater than from Bald Hill.

The successful manufacture of Oxyd of Zinc for paints, is now established at three or more points on the Atlantic seaboard, and the demand for it rapidly increases as the public becomes convinced of the superiority of the paint over lead and barytes. The process of manufacture is extremely simple, and requires less expense and labor than the production of the metal. The ore chiefly used is the mixture of red oxyd of zinc, silicate of zinc, and the iron ore called Franklinite, which itself contains about 25 per cent. of oxyd of zinc. At Bethlehem, Pa., the electric Calamine—a silicate of zinc oxyd—is largely used, and the metal is made from it.

The ores first mentioned are obtained in Sussex County, New Jersey, where they occur in thick beds, between strata of white crystalline limestone, supposed to be metamorphosed Lower Silurian. These beds of ore are in great plicated folds, as I have determined after extended examinations in detail; and they have already been worked to a depth of three or four hundred feet without any special change in the character or quantity of the ore. It is a very hard ore, and is daily becoming more expensive to mine. It requires to be transported nine miles in wagons, to the Morris Canal, by which it is taken to Newark, to the works of the New Jersey Zinc Company, and to the establishment of the Passaic Zinc Company, at Jersey City, opposite New York. Both of these large establishments are in full operation, producing several thousand tons of white oxyd of zinc, every year. The ore, as delivered there, is in hard blocks, and requires heavy machinery and stamps for crushing it to powder, preparatory to its being mingled with fine coal and ignition in furnaces, where the oxyd is produced. The ore, as already observed, contains a large amount of iron, and its percentage in zinc is further diminished by carbonate of lime, and silex in combination with the zinc. Its average yield, in working, is about thirty per cent. of oxyd, a portion being unavoidably retained in the ferruginous residue and the slag.

Compared with the New Jersey ore, the carbonate from Bald Hill has the following advantages for the manufacture of zinc oxyd or the metal: First, greater per centage of zinc oxyd; second, freedom from a large proportion of iron oxyd and silex; third, ease with which it may be reduced to powder after being calcined; fourth, cheapness of mining and transportation.

It is also a richer ore than that used at Bethlehem, which contains about 25 per cent. of silex, and consequently cannot be concentrated by calcination like the carbonate, and is more difficult to work in the furnaces. Notwithstanding these difficulties, however, the manufacture of the metal and the oxyd has been entirely successful, the latter being the most profitable product. The metal made was superior to any in the market, and has been much sought for on account of its purity.

New Haven, *May* 6, 1860.

ART. III.—REPORT OF THOMAS PETHERICK, ESQ., OF POTTSVILLE, PA., UPON THE SILVER HILL MINE, DAVIDSON CO., N. C.,

WITH THE CHARTER AND BY-LAWS OF THE SILVER HILL MINING COMPANY.

This important concern is situated about ten miles in a Southerly direction from the North Carolina Railroad Depot at Lexington, whence there is a good road to the Mine, which is situated in a rolling healthy country.

The quantity of land belonging to the Silver Hill Mining Company is one thousand and twenty-six acres, more than two-thirds of which is mostly valuable for mining purposes.

Considering the great extent of the estate, its mineral properties and probable capacity of production, it has been but very imperfectly developed; the present mining works occupying but a trifling portion of its area.

The mining operations, with an unimportant exception, have been confined to *two* veins, represented by the accompanying transverse section, Section 1, named respectively the "east vein" and the "west vein," which are separated at the principal shafts by rock varying in thickness from about eight to nine yards. Their principal production has been argentiferous lead ore, (the bullion from which contains an important proportion of gold,) but, considering the great length of time which has elapsed since the mine was first opened, the mining operations have been extremely limited, for although, with two short intervals of suspension amounting together to little more than a year, the mine has been in operation about twenty-two years, yet the deepest level or "tunnel" is only about one hundred yards below the surface, and the length of the different levels only about one-half that extent, the whole amount of ground opened from the surface to the bottom of the mine, in the long period of say twenty-one years being but from eight to nine thousand superficial yards.

Besides the argentiferous galena, those veins have also yielded the sulphuret of silver, and native silver, and blende or sulphuret of zinc, the latter abundantly in the shallow parts of the mine, where the carbonates and phosphates of lead also occurred. The blende, which, as before stated, was abundant in the shallow workings, has, in the deeper parts of the mine, greatly decreased in proportion relatively to that of

the argentiferous galena, which appears to increase materially in the lower openings. When I made my examination the pump shaft, on the "east vein," was sunk about eight yards below the bottom level, and it is very satisfactory to observe, that there—in the very bottom of the mine—the vein was well charged with rich argentiferous galena.

The rock of the country at the mine, is mostly an indurated silicious and argillaceous schist.

The two veins referred to, the "east vein" and the "west vein," are separated at the principal shafts by about eight to nine yards of rock, as shown in the transverse sections, Section 1, but it is very probable that at at no great distance longitudinally from the present openings they will form a junction. It is important that explorations should be made to prove this as the effect of such junction in most mines is generally very advantageous in regard to increased productivenesss.

It seems strange that an object of such obvious importance should have been so long neglected. Another very important object appears also to have been overlooked—a proper course of exploration to prove what other mineral veins there may be in the Company's extensive property. From the surface circumstances this will be attended with very little expense, relatively to its importance, and I recommend this being undertaken speedily after a proper examination and consideration of the subject.

The longitudinal section, Section 2, shows the workings on the "east vein," the blank spaces representing the unwrought ore ground in this part of the mine, (that remaining by the shaft from the two hundred and fifty feet, level upward, being left unwrought to support the shaft.) The longitudinal section, Section 3, is a similar representation of the "west vein."

The matrix in which the argentiferous galena occurs in these veins, is mostly silicious and talcose schist, with some quartz. Copper pyrites occurs but sparingly. The "east vein," which has hitherto proved most productive, and which has been most extensively worked, is *six to seven feet thick*. The "west vein" is from *ten to eleven feet thick*. Their general bearing is about N. N. E. and S. S. W. with an average "underlay," E. N. E. of three and a half to four feet in a fathom. In measuring depth the veins fully maintain their size and strength, and improve in regard to the character of the mineral; the silver lead ore increasing in proportion to the accompanying inferior zinc ore ("blende,") which proves to be decreasing. That increase of the proportion of the former appears to have been

decided from the two hundred and fifty feet level downwards to the bottom of the mine.

On the "east vein" in the lower openings, there occurs a leader of soft whitish argillaceous substance enveloping native silver, sulphuret of silver and rich argentiferous galena.

In the deepest working on the "West Vein" in a winze about five yards below the bottom, or three hundred feet level, *the vein is large and promising, and well charged with the same valuable ore.* It will be seen by the longitudinal sections of these veins, Sections 2 and 3, (and it is most important to keep this in view,) that the different levels are driven, either merely in the productive ground, or very little indeed beyond that ground. In lead, copper and most other metallic mines, the productive or ore grounds form but a moderate portion of the area or face of the veins; the ore being in detached isolated "bunches" or patches; and in mines where theunderground operations are conducted by persons of sound mining experience and judgment, the driving of the levels through a great extent of "dead ground," between the "bunches" of ore, is looked upon as a matter of course. To rely on a single "bunch" would be considered to be decidedly impolitic and inexpedient, as well as unminer-like. Such, however, has been the case in this concern, with one, and that not a very important exception—the opening at Symon's shaft, about three hundred feet northerly from the present working shafts. There, a considerable time ago, a shaft was sunk and a level driven, about ten fathoms deep, and there was another opening there a few fathoms deeper, but those trials were of very limited extent. There is no mine that I am aware of, that could yield any benefit to the proprietors worked in the same inefficient and unminerlike manner this has been.

Those trials at Symon's shaft were not accessible for examination during my visit, but the prospects developed are represented as being very satisfactory. The vein stuff which I saw at the surface there, including some copper pyrites, was of a *very promising description.*

There is a large quantity of zinc ore ("blende") on the surface of the mine, from the former dressing operations, which it is understood can be disposed of at a profit. It will probably be found desirable to adjust those operations in future to rendering this description of ore available with the greatest advantage.

At a distant part of the property from the present operations a gold vein was opened some months since, which is represented as deserving a further trial.

Machinery. There are two high pressure steam engines in operation at the mine, one of fourteen inches diameter cylinder, five feet stroke, rated as a sixty h. p. engine, with two boilers thirty feet long, two and a half ft. diam., in very good order; and three boilers of the same dimensions, which require repair. This engine pumps the water of the mine, drives an ore crusher, and works an eighteen heads stamps and saw mill. The other engine, eight inch diameter cylinder, is supplied with steam from the same boilers. It works ten round buddles, and it is intended to attach a rotating buddle also, to it. There is a locomotive boiler on the ground intended to be applied to it. The pump work consists of a forcing or "plunger" lift, seven inches with six inches diameter pipes, one hundred and sixty feet length, and two six and a half inches drawing lifts, with seven and a half inch pipes respectively one hundred and forty feet length.

Buildings. A very extensive building, covering the steam engines, the crushing, stamping, and ore dressing machinery, and saw mill; smith's and carpenter's shops; office, laboratory, and storehouse; Superintendent's and other good dwelling houses; a great number of miner's houses and negro quarters; stabling, &c.

I have stated in the early part of this report the extraordinarily slow progress, in depth, of the mining, say one hundred and fifty fathoms in about twenty-one years; but since referring to a report of the mine made in 1845, by Mr. R. C. Taylor, I believe that he spoke of the deepest shaft being then "in process of sinking some forty or fifty feet lower than the one hundred and sixty feet level." From this it appears that during the fifteen years which has since elapsed the rate of sinking has not much exceeded a fathom a year!

In the absence of information as to the extent to which the early operations of the concern may be carried, for placing it upon a more effective and advantageous footing, I am not prepared to give a proper estimate of the appropriate outlay. I consider, however, that not less than $20,000 should be forthcoming for that purpose; and in all probability early developments will satisfy the company of the expediency of a larger expenditure for *speedily availing themselves, to an adequate extent, of the advantages of the undertaking; the prospects of which I consider to be highly satisfactory,* if it be conducted with spirit and judgment.

Respectfully submitted by

THOS. PETHERICK,

Mining Engineer, &c.

POTTSVILLE, *Penn., May,* 1860.

CHARTER.

SEC. 1. Be it enacted by the General Assembly of the State of North Carolina, and it is hereby enacted by the authority of the same, that Franklin Osgood, Henry Schoonmaker, William Borrowe and their associates, successors, and assigns, are hereby created and constituted a body corporate by the name and style of the Silver Hill Mining Company, for the purpose of exploring for Silver, Copper, Lead, Iron, and other metals and minerals, and for mining, vending, smelting and working the same, and by that name may sue and be sued, plead and be impleaded, appear, prosecute, and defend in any Court of Law and Equity, whatsoever, in all suits and actions; may have a common seal, and the same alter at pleasure, and may enjoy all the privileges incident to Mining Corporations, and may purchase, hold and convey real and personal estate to an extent not exceeding one million of dollars.

SEC. 2. Be it further enacted, that the first meeting of said Corporation may be called by the persons in this act, or any two of them, at such time and place as may be agreed upon, by the persons named in this act, and at such meeting, and at all other meetings legally notified, said Corporation may make, alter, and repeal, such by-laws and regulations for the management of the business of the said Corporation, as a majority of the Stockholders may direct, not repugnant to the laws of this State nor of the United States.

SEC. 3. Be it further enacted, that the said Corporation may divide their original stock into such number of shares, and provide for the sale and transfer thereof, in such manner or form as said Corporation shall from time to time deem expedient, and may levy and collect assessments, forfeit and sell delinquent shares, and declare and pay dividends on the shares.

SEC. 4. Be it further enacted, that it shall be the duty of the Directors of the said Company, one of whom shall reside in this State, to have regular books of record and transfer kept by the Secretary, or Treasurer thereof, at all times open to the investigation of the Stockholders.

SEC. 5. Be it further enacted, that this Corporation shall exist for fifty years, and the act be in force from and after its passage.

BY-LAWS.

ARTICLE I.

The capital stock of the Company shall be divided into two hundred thousand shares, the par value of which shall be $5 per share.

ARTICLE II.

The Board of Directors shall be composed of seven stockholders, one at least of whom shall be a citizen of North Carolina.

The Directors shall be elected at an annual meeting of the stockholders to be held on the third Tuesday of May in each and every year, and shall serve for one year, (unless sooner removed,) and until others shall be elected to fill their places, by a subsequent meeting; *provided*, that if vacancies occur in the Board, any number not less than three may continue to act until the Board or the stockholders shall fill the vacancies. All notices of each annual election shall be published in at least two of the daily papers of this city, for not less than ten days previously, and the books of the Company shall be closed for five days, to terminate on the day on which the election shall be holden.

ARTICLE III.

The officers of the Company shall be a President, Vice President, Treasurer, and Secretary, to be elected by the Board of Directors, who shall fix their compensation.

ARTICLE IV.

The President shall be the chief executive officer of the Company, and have the general supervision and control of its other officers, employees, operatives, business, and property, subject to the direction of the Board of Directors, who shall hold bi-weekly meetings at the Company's office, at such hours as the Board shall direct. At his discretion he may employ or remove all operatives, or suspend any officer, and dispose of the products of the mine; the suspension of any officer shall be promptly reported to the Board, for its action. By and with the advice and consent of the Board, he shall appoint and remove all officers of the Company, purchase all

such machinery, implements and other things, as may be necessary to carry on its business, and make contracts, and sign bonds to fulfill the same, for and in its behalf.

In case there shall be no Treasurer, he shall act as such, and no money shall be paid out of the Treasury without his written approval.

The President shall preside at all meetings of stockholders, when present; if not, any stockholder may be appointed by the meeting to preside.

In the absence of the President, or on the failure of the Board to fill that office, the Vice President shall exercise all his powers, and perform his duties.

ARTICLE V.

General meetings of the stockholders may be called at any time, by the President or by the Board of Directors, or stockholders holding one-fourth part of the stock, and shall be held at such place as he or they may designate in the call.

Stockholders shall be notified of every meeting by a written or printed notice addressed to each at their respective places of residence or business, and deposited in the Post Office five days before the meeting, or by advertisement in two daily papers published in New York, and one in Baltimore, at least two days before the meeting.

The stockholders may remove the President or any Director from office and appoint others to fill their places.

The Treasurer of the Company or other officer acting as such, before proceeding to act, shall give bond to the Company, with security, to be approved by the Board, in the penalty of $15,000, for the faithful performance of the duties of his office.

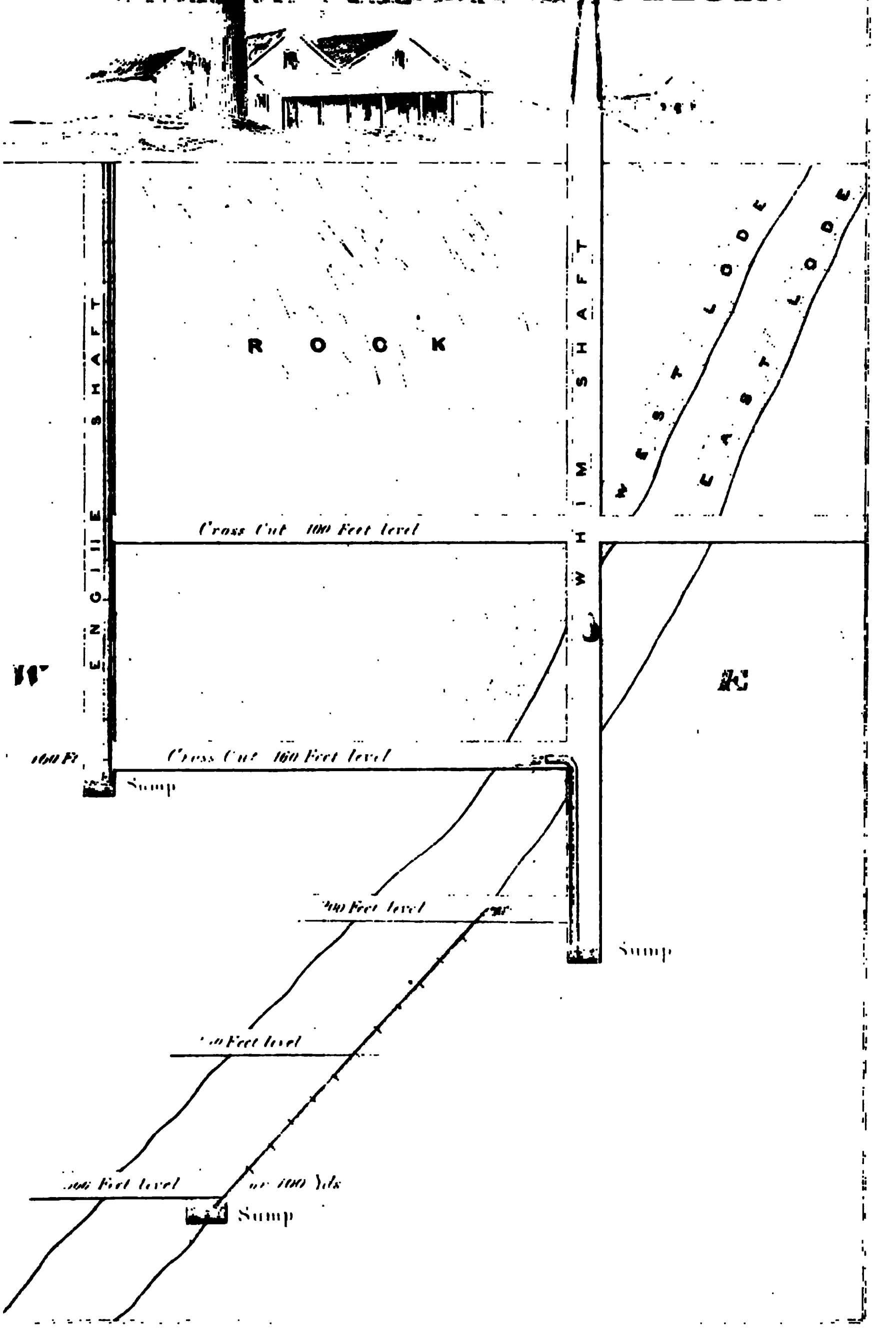
ARTICLE VI.

The office for the general management of the affairs of the Company, and the place of meeting of the Board of Directors, shall be in the City of New York.

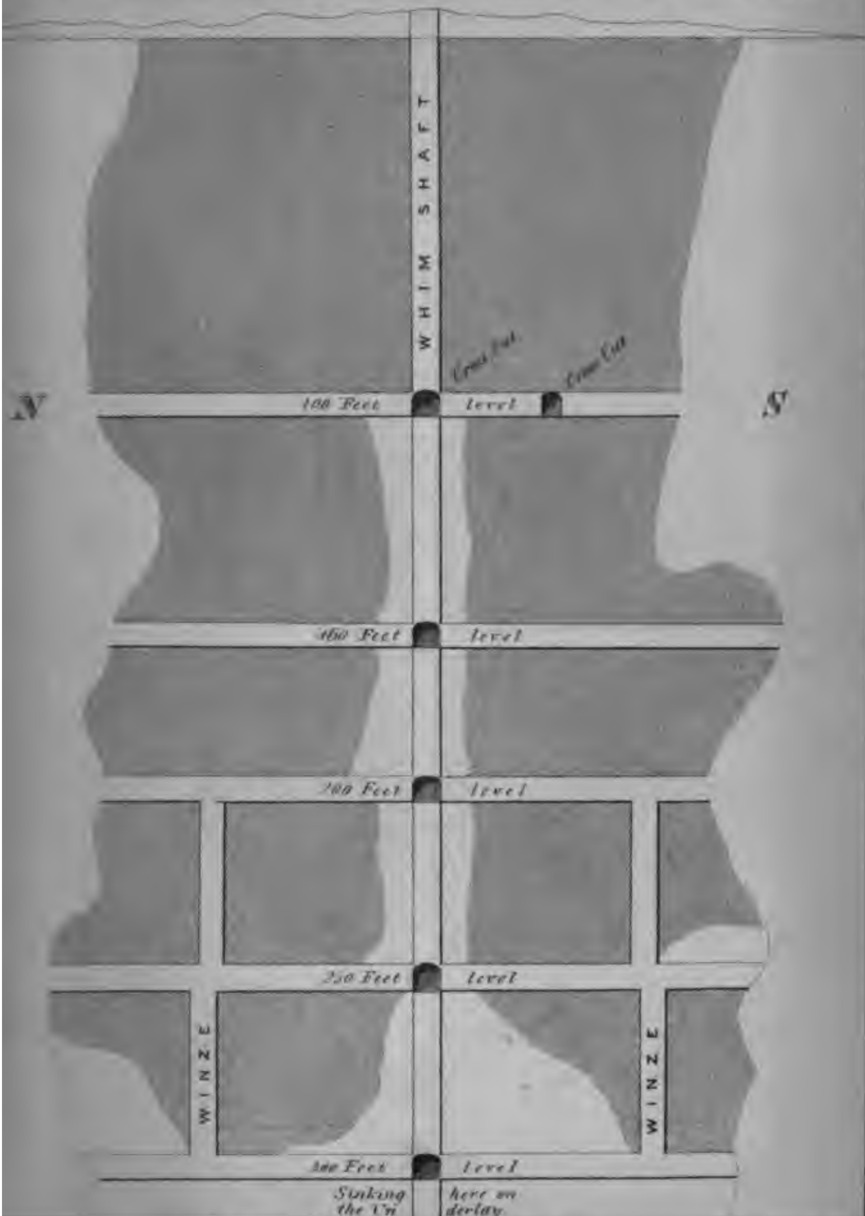
ARTICLE VII.

The account books of the Company shall be open to the inspection of any Stockholder at all times, and a statement of the condition of the property and the financial affairs of the Company shall be made to any meeting of Directors, or Stockholders, by the President or Secretary, whenever required by a Stockholder.

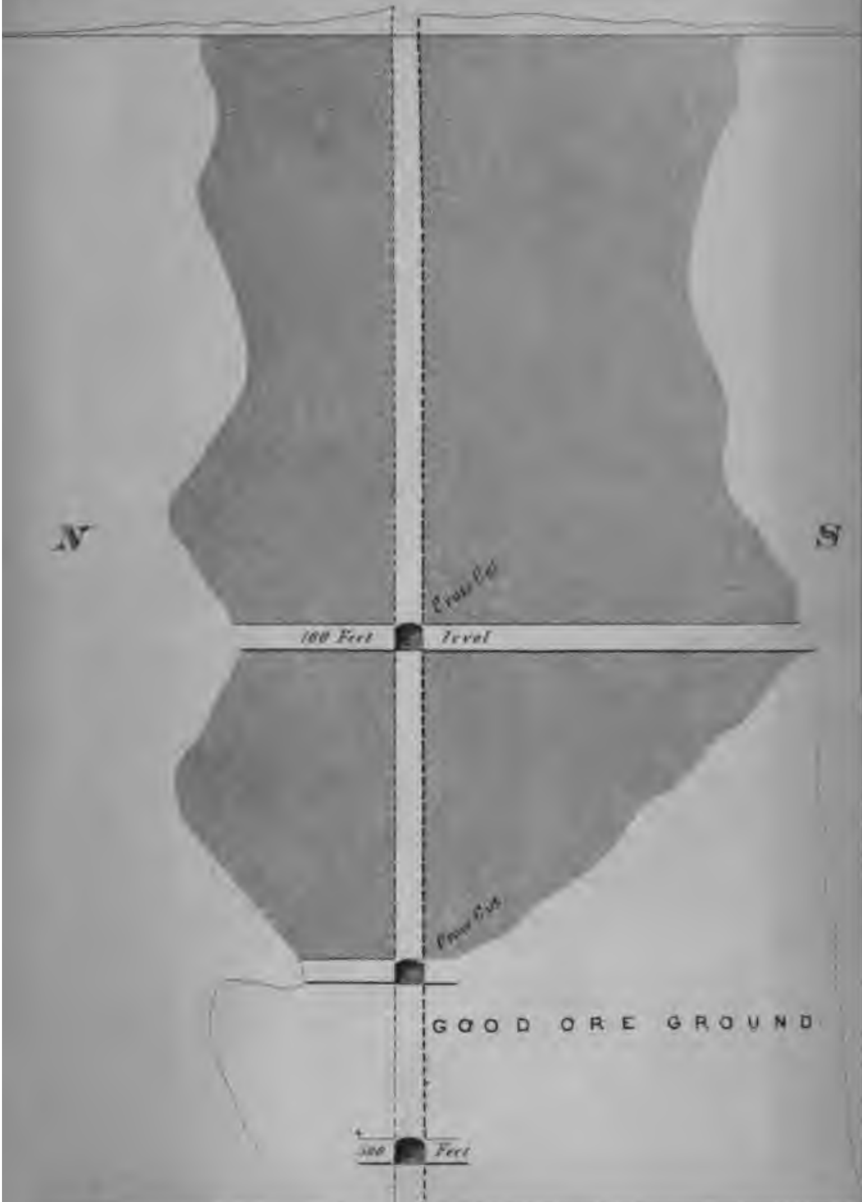
SECTION 1.
TRANSVERSE SECTION.



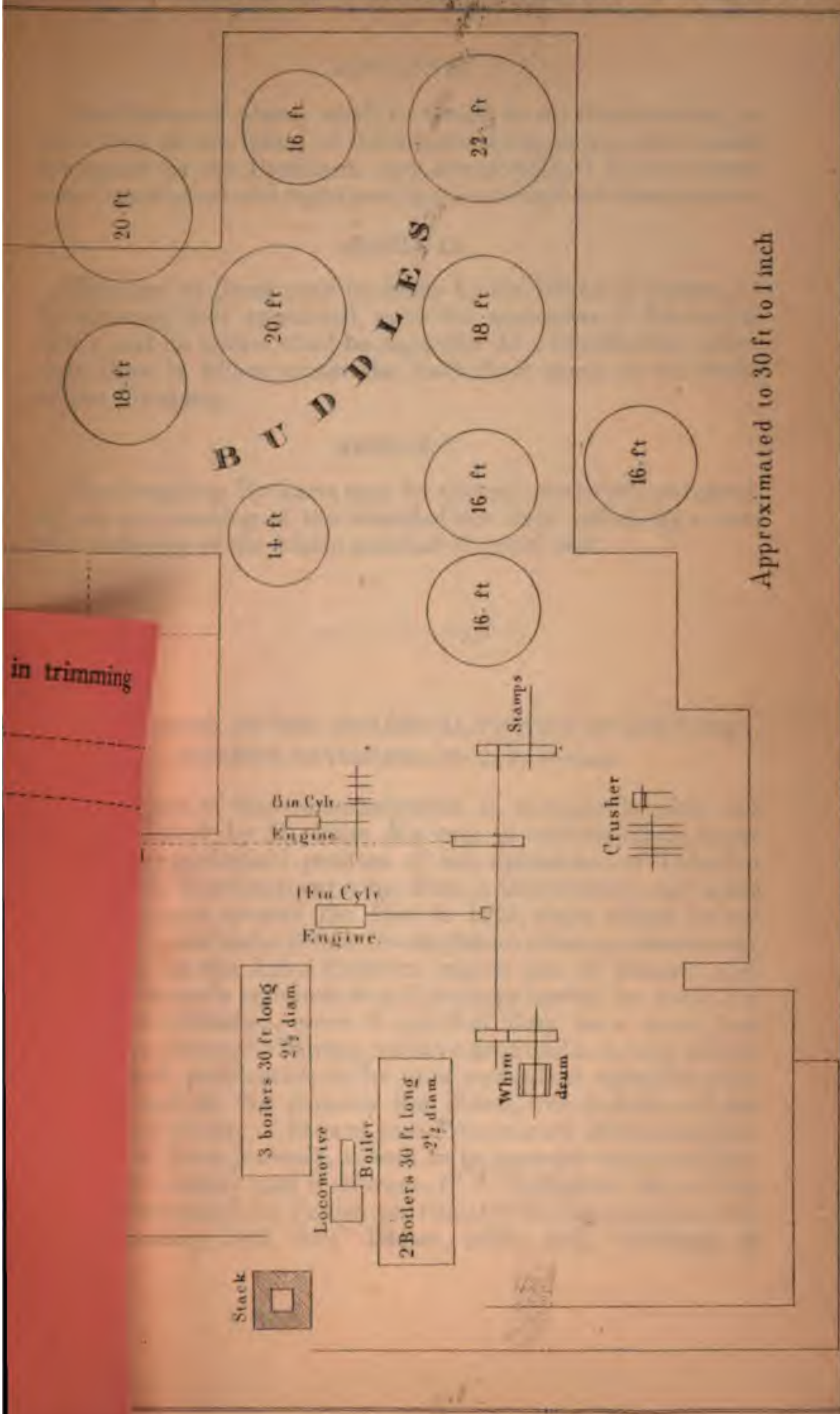
SECTION 2
LONGITUDINAL SECTION OF THE EAST VEIN.



SECTION 3
LONGITUDINAL SECTION OF THE WEST VEIN.

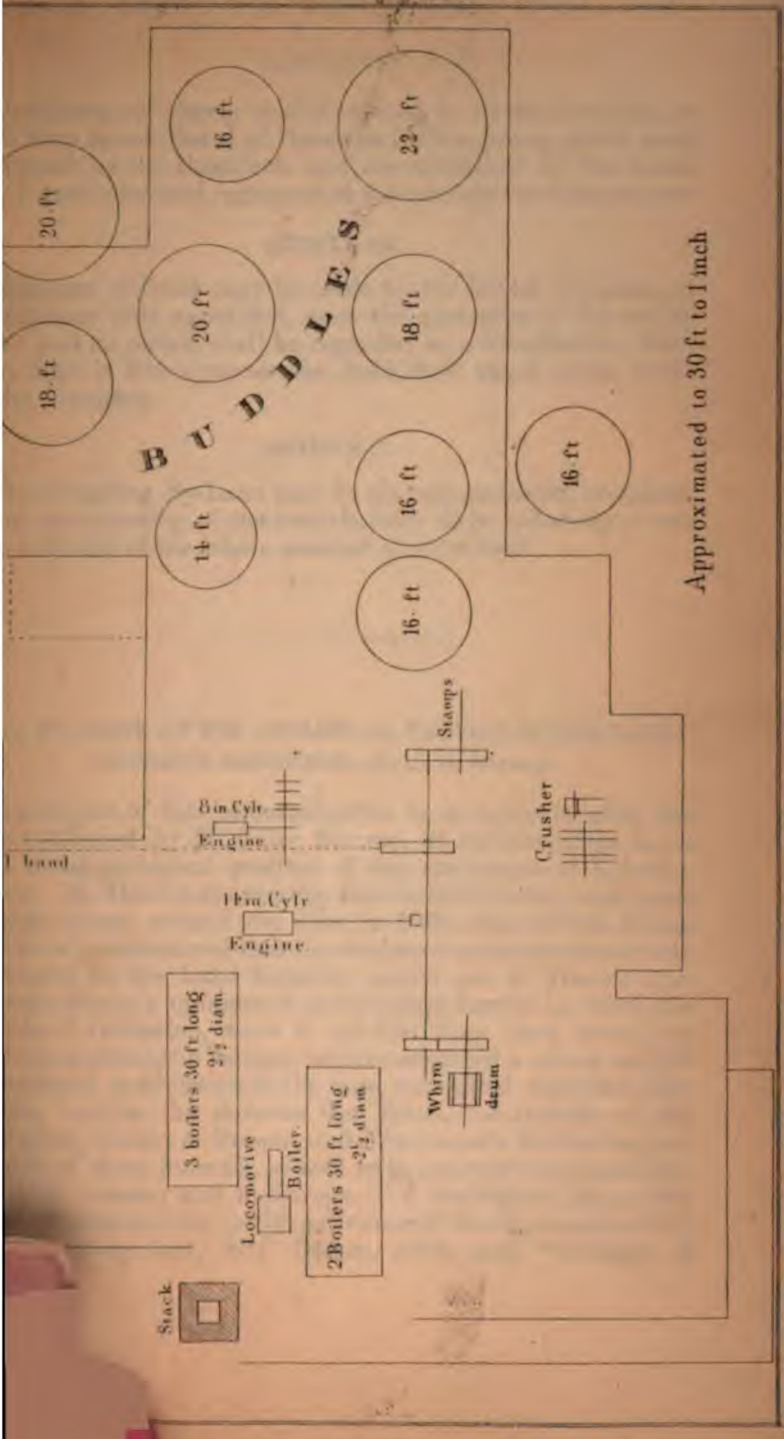


ILVER HILL MINE, DRESSING ARRANGEMENTS.

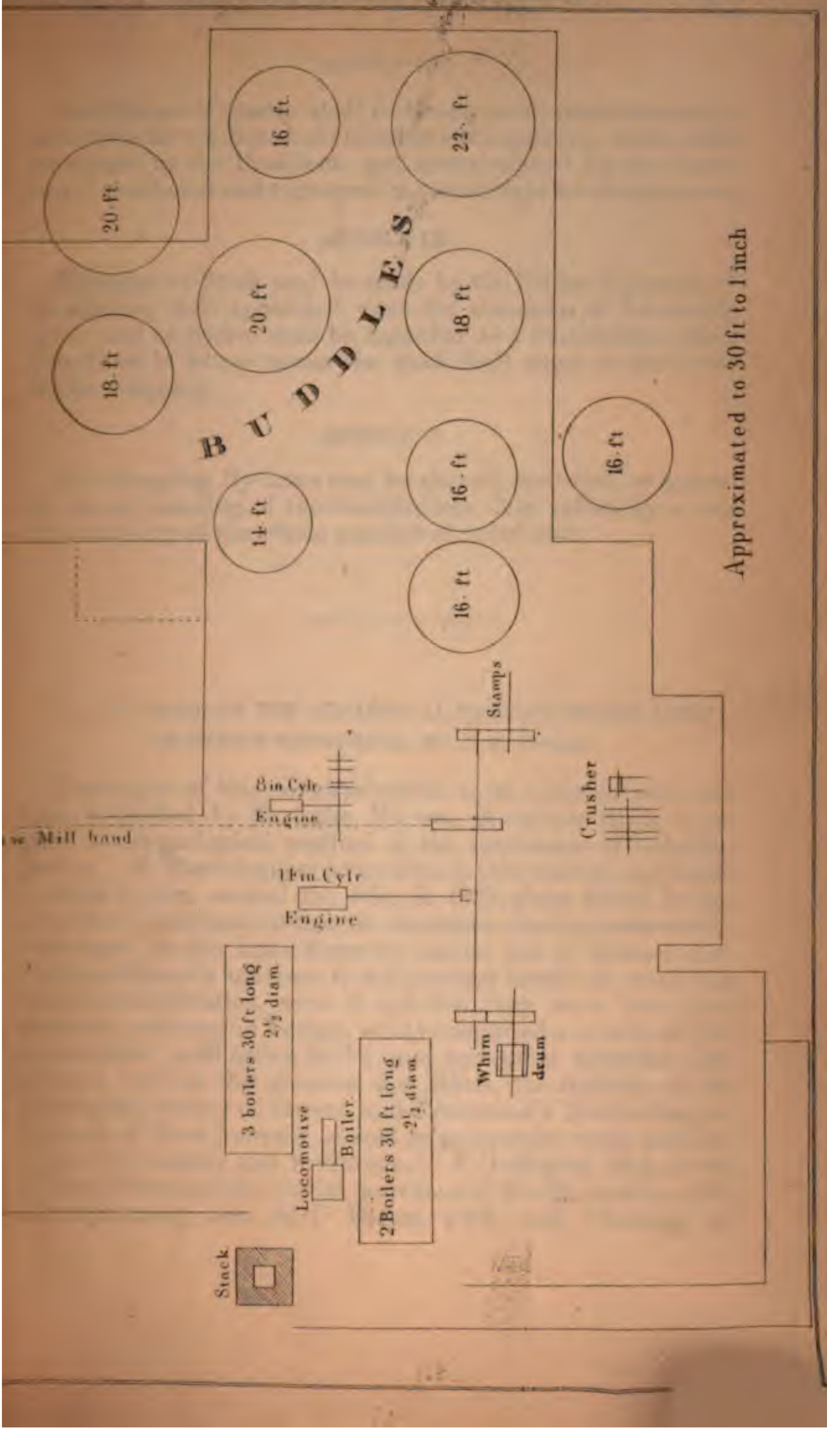


in trimming

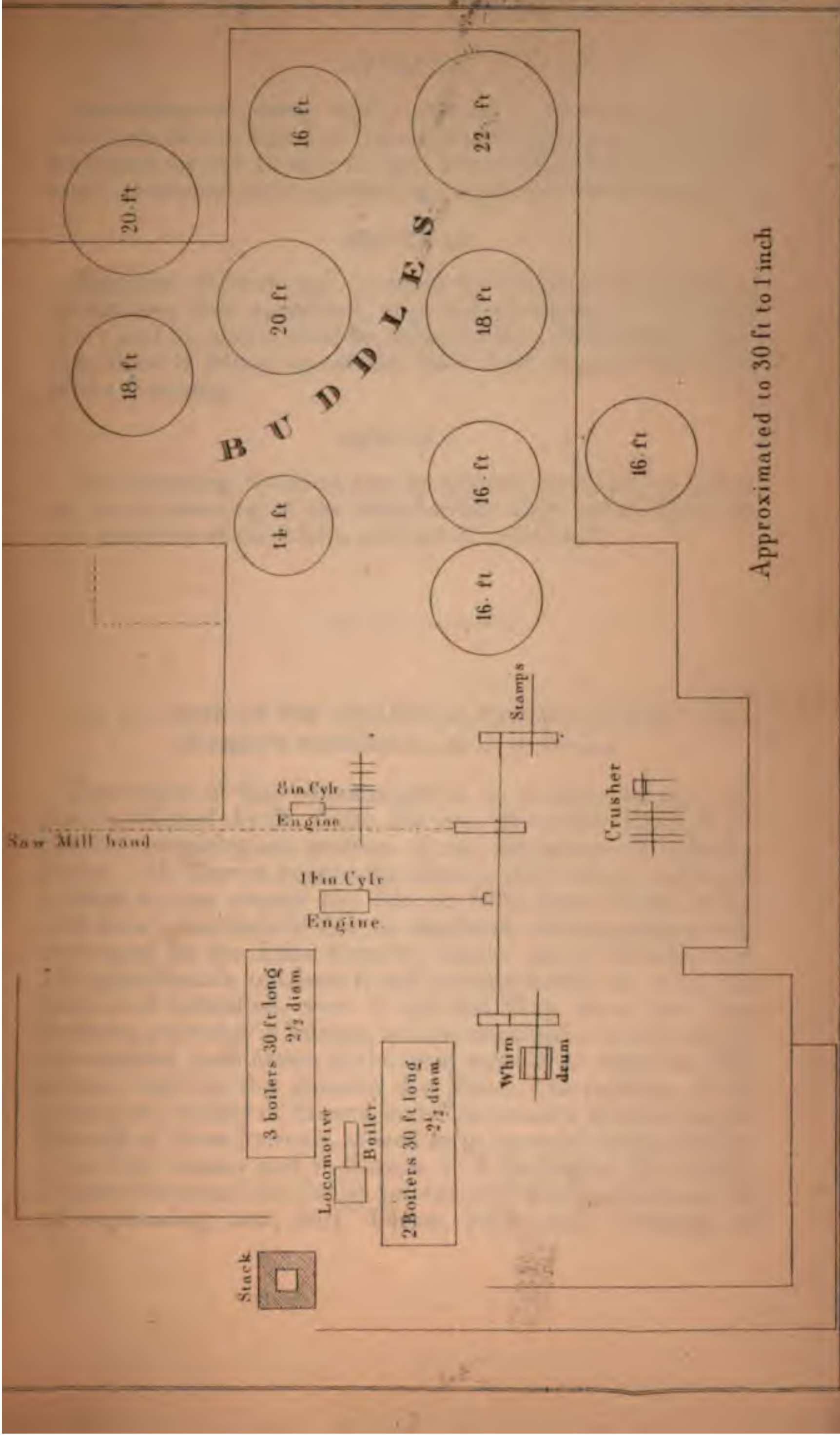
ER HILL MINE, DRESSING ARRANGEMENTS.



ILVER HILL MINE, DRESSING ARRANGEMENTS.



SILVER HILL MINE, DRESSING ARRANGEMENTS.



ARTICLE VIII.

Certificates of shares shall be issued to all Stockholders, in such form as the Board of Directors shall approve, which shall be signed by the President, and countersigned by the Secretary; numbered and registered in a book kept for that purpose.

ARTICLE IX.

Transfers of Stock may be made by the holder in person, or by attorney duly appointed, upon the surrender of the certificate; and no person shall be regarded as a Stockholder, other than those in whose names the stock shall stand on the books of the Company.

ARTICLE X.

The foregoing By-Laws may be altered, amended, or repealed, at any meeting of the Stockholders duly called, by a vote of a majority of the whole number of votes cast.

ART. IV.—NOTE ON THE GEOLOGICAL POSITION OF THE LAKE SUPERIOR SANDSTONE.—BY J. D. WHITNEY.

THE object of this communication is, to reply to what has been published by M. Jules Marcou, at various times, in regard to the geological position of the sandstones of Lake Superior. M. Marcou spent some time in this country, and made a canal voyage around the lake in 1848, since which he has strenuously maintained that the sandstone strata so extensively developed in the Lake Superior region are of Triassic age. This gentleman's opinions would perhaps hardly be worth the trouble of refutation, were it not that they have been, in a measure, endorsed in Europe, or have acquired a certain weight by repeated publication in the most accredited scientific periodicals, such as the Annales des Mines, the Bulletin of the Geological Society of France, and Petermann's Mettheilungen. In each of these journals, as well as in separate works published in this country and in Europe, ("A Geological Map of the United States and the British provinces of North America, with an explanatory text, &c;" Boston, 1853; and, "Geology of

North America," Zurich, 1858,) M. Marcou has given to the world a geological map of the United States, on which, among many other astonishing misconceptions and misrepresentations, not to say, willful falsifications, of American geology, he has laid down a belt of Triassic, or new red sandstone rocks, extending from Saut St. Marie westward, covering a vast expanse of territory in Minnesota, Kansas and Nebraska, and reaching far down into Texas on the South, and New Mexico and Utah on the West and Southwest.

If we seek through M. Marcou's works for the geological evidence by which the existence of the Triassic over a region as large as France and Germany together is supported, we find ourselves completely at a loss to discover a single fact which would justify the representation of this formation in any portion of this vast territory, while the proof that it does not exist over a large extent of surface, where it has been laid down by him, is overwhelming.

In the terra incognita of the Rocky Mountains, there may have been, at the time of the publication of M. Marcou's first map, some excuse for hasty generalization and wholesale laying down of geological groups from lithological resemblance only, but in regard to the Northwest, there was no such uncertainty, or room for the substitution of fancy for fact. The whole region of Lake Superior had been for years undergoing investigation at the hands of three different geological corps; the published results of these investigations were in M. Marcou's hands; the conclusions arrived at, independently by each of the corps, were entirely adverse to the views supported by him. It required no small amount of self-confidence thus to substitute conclusions arrived at, after a few days of observation, made by one person, for those which were the mature results of protracted investigations, carried on by a large number of explorers, and extending over a period of several years. Let us consult M. Marcou's latest publication on the subject of American Geology, to see what his reasons are for ignoring the results of American geologists, in thus deciding the age of the Lake Superior sandstone, contrary to their unanimous opinion.

In the "Geology of North America," (p. 10,) we find this question taken up and discussed, and for convenience we will quote what M. Marcou has written in defence of his opinion that the sandstone of Lake Superior is of Triassic age, replying to each of his arguments in order. We are first enlightened by the following paragraph which conveys the official dictum, so to speak, of M. Marcou, as self-elected geologist of North America.

"Dr. Charles T. Jackson first announced the existence of the *New Red Sandstone* or *Trias*, at Lake Superior. Struck with the resemblance between the sandstone of Lake Superior and those of the shores of Maine,(!) New Brunswick and Nova Scotia, he did not hesitate to refer them to the same formation, notwithstanding the contrary opinion of Bayfield and Logan, who had considered them as either *Old Red Sandstone* or *Potsdam Sandstone*. Dr. Jackson made a discovery in 1848, that confirmed the justice of his first view; he found at *L'Anse*, near the mouth of Sturgeon river, in Keweenaw Bay, beds of magnesian limestone filled with *Pentamerus oblongus*, and consequently of the Upper Silurian epoch, *much upheaved* and surrounded by *horizontal beds* of the red sandstone of Lake Superior. In 1848, I made the complete tour of Lake Superior and carefully studied this question: my observations agreed entirely with those of Dr. Jackson, and I at once adopted his opinion."

After reading the above, will it more amuse or surprise the reader to learn that neither Dr. Jackson or M. Marcou ever saw the locality of limestone thus mentioned as affording the evidence, *and the only evidence*, of the existence of the Triassic in the Lake Superior basin, and in regard to which *M. Marcou's observations agreed entirely with those of Dr. Jackson!*

The facts connected with the discovery and description of this limestone deposit are simply these: The locality in question was first visited by C. C. Douglass, and the limestone discovered by him in 1846; it was afterwards definitely located on the map by the linear surveyors, in running the town or section lines in the vicinity of the Anse. It was visited by the writer of this communication in 1848, carefully examined, and the facts reported to Dr. Jackson, who at that time was at the head of the Lake Superior survey. The only knowledge Dr. Jackson ever had of this limestone was derived from my field notes, in which it is distinctly stated that the deposit was of Lower Silurian age, and that the exposures at the locality were not sufficient to entitle me to say anything definite about the relative age of the limestone and the circumjacent sandstone. That was a question which must be settled by farther observations at other points, although it was intimated that the stratigraphical relations of the two formations were such, that the limestone might be the oldest.* My notes, however, never authorized Dr. Jackson or anybody else to draw any positive

* See Docs. acc. Pres. Message, 1854, vol. iii, p. 625.

conclusions as to the relative age of the sandstone and limestone, taking into consideration only the phenomena observed at that particular locality. But we have, on the other hand, the most abundant evidence, from numerous observations made along the line of contact of the sandstone and the underlying Azoic rocks, that there is no limestone formation intercalated between the two, as there must be if Dr. Jackson's theory were correct. Farther explorations in the vicinity of the limestone deposit, the necessity of which was insisted on by me in my notes, showed afterwards that its dip was undoubtedly due to local disturbance caused by igneous masses below. Other instances were discovered in that region, where the trappean rock may be seen disturbing the sandstone and giving it a slight dip, just as it has the limestone beds in question, only that, in the latter case, the igneous mass does not make its appearance at the surface. In this way the relative position of the two formations was satisfactorily explained, the limestone being seen to be an outlier which had escaped denudation from the circumstance of the strata having been locally elevated in that immediate vicinity. There were no specimens of *Pentamerus oblongus*, or of any other Upper Silurian fossils, found at this locality; they were all Lower Silurian; but, admitting that they were Upper Silurian, and that the stratigraphical relations of the two formations were as maintained by M. Marcou, that would not prove the sandstone of Lake Superior to be of Triassic age. It might be Devonian, or Carboniferous, or anything else above the Silurian. We have thus disposed of M. Marcou's direct evidence as to the Triassic age of the sandstone in question, and we will quote his next paragraph, in which he resumes the observations presented by the geologists of the Northwest in support of their views on this question, accompanying his *résumé* with critical remarks, on which we shall take the liberty of commenting. We continue our quotation from page 11 of M. Marcou's book, as follows:

"Foster, Whitney, James Hall, Norwood, Whittlesey, and Owen, in their Reports upon the Geology of Lake Superior, published in 1851 and 1852, have maintained the old opinion as to the age of the sandstone formation of Lake Superior, synchronizing it with the Potsdam sandstone of the New York Survey, although their reasoning in support of this determination is entirely inconclusive. It may be thus resumed. The *Potsdam sandstone* with the *Lingula* and *Trilobites* characteristic of the formation, is found on the rivers Escanaba, Menomonee, and Sainte Croix, to the south of the line dividing the waters of Lake Superior, Lake Michigan, and the Mississippi river.

A sandstone containing *Lingula prima* has been found in Tequamenon Bay, Lake Superior, and therefore this sandstone is of the same age as the Potsdam. It is true, they add, that the sandstone of Lake Superior is never seen in intimate connection with, and continuation of, the strata of the Escanaba and St. Croix rivers; but the reason of this is found in the existence of a chain of eruptive rocks which was interposed before the deposit was formed."

We pause in our quotation to remark simply, in reply to what is asserted above by M. Marcou, that the sandstone of Lake Superior *is* seen "in intimate connection with, and continuation of," the strata of Potsdam Sandstone of the Escanaba and St. Croix rivers, as will be recognized at once by referring to the geological map of the Lake Superior Land District, accompanying Foster and Whitney's Report, Part II, on which a broad belt of sandstone will be noticed stretching continuously along the shore of the Lake, branching, near Chocolate river, to the southwest, and crossing the Escanaba and Menomonee rivers, without a break or interruption, whence its course may be traced on Dr. Owen's maps, entirely and continuously around to the St. Croix. Either M. Marcou has never consulted the published maps of the region whose geology he is discussing, and this portion of which he himself never set foot on, or else he considers that which was given to the world as the results of the United States Survey, made under the direction of Dr. Owen and Messrs. Foster and Whitney, as purely imaginary and fictitious. In short, it is the simple opinion of one who has not seen the country, as to what the geology ought to be to satisfy his theoretical views, set in opposition to what the geology really is, as developed by the careful explorations of several independent observers, who have no conceivable motive for representing the facts otherwise than as they really are.

With these remarks on the first point attempted to be made by M. Marcou, we resume our extract from his work,—omitting nothing, and quoting *literatim et verbatim.*

"As to the *mineralogical character* and *thickness* of the formation, although they [Foster, Whitney, &c.] admit very *striking differences*, they are *rejected* as not being *available* in the determination of stratified rocks."

We here remark, that "mineralogical character and thickness" are *not*, in the estimation of modern geologists, "available in the determination of stratified rocks," if by that is meant, as can only be meant, the determination of their geological position. This we conceive to be one of the fundamental

principles of geology, and cannot think it necessary to spend a moment in arguing the point. It is *not* true, however, that we "admit striking differences," if this obscure expression be understood in the only sense in which it would have any meaning at all, when taken in connection with the rest of the paragraph, namely, that there are striking lithological differences between the sandstone of Lake Superior and that of the Menomonee, Escanaba, and St. Croix rivers, and other localities in the Northwest, admitted by M. Marcou himself to be of Potsdam age. The fact is, that there is no essential or noticeable difference in lithological character, or in thickness, between the sandstones of Lake Superior and those "to the south of the line dividing the waters of Lake Superior, Lake Michigan, and the Mississippi river." The traveler who coasts along the southern shore of the lake, from one end of it to the other, will see nothing in the lithological character of the sandstone which would lead him to separate it from the Potsdam sandstone of Wisconsin and Minnesota; nor will he find any change in this respect on exploring the country back from the Lake shore, any where between Saut St. Marie and the extremity of Keweenaw Point, that is to say, for nearly two-thirds of the distance from one end of the Lake to the other. It is only in connection with the trappean rocks, from Keweenaw Point westward, that those "differences" exist which we have fully described in our Reports, and shown to be due to the influence of the igneous masses, but which will in no wise justify us in separating the sandstone, where it is changed in character by the proximity of trap, from the same rock at a little distance on either side, where it passes gradually into its normal condition. As well might the geologist call the metamorphosed rock, for a few feet or inches on either side of a trap-dyke in the Connecticut valley sandstone, Triassic, and that portion to which the influence of the intrusive mass has not penetrated, Potsdam.

M. Marcou, having thus resumed, as he thinks, the evidence presented by the geologists of the Lake Superior region in favor of this view of the age of the sandstone in question, proceeds to reply to their arguments, as stated by himself. We continue our quotation:

"To this I reply—that the Potsdam sandstone is found south of the dividing ridge referred to above, on the banks of the rivers Escanaba, Menomonee and Sainte Croix, is not disputed; but Foster, Whitney, and Hall have forgotten to mention that the sandstone with *Lingula prima* found at Tequamenon bay, was a fragment taken froma *boulder* by Forrest Shepherd, in 1845,

and that neither before or since has any fossil been found in the strata *en place* of Lake Superior. Consequently, Paleontology cannot be invoked to aid the determination of the age of this sandstone."

To this it may be replied, that even if the specimen found by Mr. Shepherd was a "boulder," as M. Marcou asserts, the fact of a loose piece of sandstone, with Potsdam fossils, having been found on the shore of the lake, would be sufficient evidence of the existence of the Potsdam sandstone somewhere in the lake basin and in the immediate vicinity, since the rock is too crumbly and incoherent to bear transportation to any considerable distance. We have, however, the authority of Mr. Shepherd himself for asserting that the rock containing the specimens of *Lingula* in question, was found by him *in situ* at Iroquois Pt., opposite Gros Cap. These specimens were given by Mr. Shepherd to Dr. Houghton, and by him to Mr. Hall, by whom they were described and figured in our Report, Part II. As M. Marcou could have had no authority for making the statement, that the rock containing the *Lingula*, found by Mr. Shepherd, was a boulder, the reader may draw such inferences as he pleases in regard to this gentleman's method of bringing the facts into harmony with his theories.

But putting aside altogether the fossils of Tequamenon Bay and the plants of the Pictured Rocks, which M. Marcou forgets to notice, we are of the opinion that the aid of palæontology may be very successfully invoked in the determination of the question at issue, by those who really desire to be enlightened, since the sandstone of Lake Superior extends in an unbroken continuous mass around to the Escanaba and Menomonee rivers, and is found to contain Potsdam fossils at those points; the nearest of which is only twenty or twenty-five miles from the shores of the lake.

But admitting the facts in regard to the Lingula of Tequamenon Bay and the noncontinuity of the sandstone to be all as M. Marcou states them, this would be, at best, only negative evidences in favor of his opinion, or absence of proof from organic remains that the sandstone was of Potsdam age. Let us endeavor to ascertain what positive evidence he has to sustain him in his theory of the Triassic age of this formation. We continue to quote M. Marcou's words, omitting nothing:

"As to the superposition, it is as we have seen in favor of Dr. Jackson's opinion, as well as the lithology and the thickness of the beds."

Here then we have again the sum total of the direct evidence offered by M. Marcou in support of his views. As we

have seen before, Dr. Jackson's opinion was based on the observations of another person, at a locality which neither he or M. Marcou ever visited, and where a more careful study of the stratigraphical position of the rocks showed, afterwards, that the first hastily expressed view of the relation of the limestone to the sandstone was not a correct one, and where, even admitting it to be so, no more could be proved than that the sandstone was more recent than Lower Silurian. Thus M. Marcou's evidence finally resolves itself into lithological resemblances only. But as the lithological character of the Lake Superior Sandstone, everywhere except in the immediate vicinity of the trap ranges, that is to say, over nine-tenths of the region in question, is identical with that of the sandstone admitted by M. Marcou himself to be of Potsdam age, then all there is left for him to fall back on is this—that a small portion of the Lake Superior sandstone, where associated with trappean rocks has a somewhat closer resemblance lithologically to some portions of the Triassic of Europe, than it has to the Potsdam sandstone of this country in its normal development.

After thus furnishing us with his opinions on the age of the Lake Superior sandstone, and the evidence by which they are supported, M. Marcou goes on to say:

"Since then, explorations, in which I participated during the year 1853, have proved that the sandstone of Lake Superior was a continuous series, and in direct relation with the beds of *New Red Sandstone* which cover and form the majority of the immense prairies bordering the rivers Missouri, Platte, Arkansas, and Red River of Louisiana. In looking at the Geological Map (see frontispiece,) it will be seen that Lake Superior formed a gulf resembling the bay of the valley of the Connecticut River, in the *Triassic Sea* which enveloped the Paleozoic continent of North America."

In conformity with these views, we find on M. Marcou's map a belt of new red sandstone laid down along the south shore of Lake Superior, rapidly widening after passing Fond du Lac, and stretching westward so as to occupy a large portion of the valley of the Red River of the North, and all the region around the head waters of the Mississippi, then bending round to the south and covering nearly the whole of Nebraska, and expanding over a fabulous amount of surface in Kansas, New Mexico, Texas, &c. Now, in reference to the Red River and Upper Mississippi region, it may be simply stated that M. Marcou never visited that portion of the country, and that no geologist has ever recorded a single observation which would justify him in assuming that the New Red Sandstone

exists there; but, on the contrary, to have abundant evidence that the region in question is occupied by Azoic and Lower Silurian rocks. In support of this assertion, we have the results of our own explorations over a portion of the territory, as well as those of Mr. Lapham, but especially the published observations of Dr. Owen and his corps, to whose authority M. Marcou ought certainly to give some weight, since he calls him "the greatest geologist now living in the United States." Alas! to what a sad plight we are reduced if the direct observations and authority of our greatest geologist will not weigh as a feather in the balance against M. Marcou's theoretical views of what our geology ought to be, to suit his own preconceived ideas!

In regard to the existence of the new red sandstone in the region of the Rocky Mountains, Kansas, and Nebraska, we can only say that no evidence, either palæontological or stratigraphical, has been presented by M. Marcou, which will allow of its being taken for granted. The recent explorations of Dr. Newberry, in New Mexico, indicate that the Triassic exists there, but detailed accounts of them have not yet been published. But as this is a region with which we are not personally acquainted, we will refer the reader, for further light on the subject, to the observations of Mr. Blake, (American Journal of Science, [2] xxii, 387,) and of Prof. Dana, (same Journal, xxvi, 329.)

M. Marcou then endeavors to support his opinion of the Triassic age of the Lake Superior sandstone by falling back on what Dr. Owen published in his preliminary report of 1848, namely, that there was "strong presumptive evidence that they [the Lake Superior sandstones] were deposited subsequently to the carboniferous era." M. Marcou remarks, "Why Owen changed his views, is quite a mystery, because, in his great and valuable work entitled 'Report of a *Geological Survey of Wisconsin, Iowa, and Minnesota*,' he places this formation of Lake Superior below the Paleozoic base of the Mississippi, without giving any proof, referring only to the Reports of J. G. Norwood, and Col. C. Whittlesey, accompanying his work, in which, nothing positive and conclusive is given, upon the age of that formation."

If M. Marcou had ever consulted the work of which he speaks in such high terms, he would have found a chapter "on the age of the red sandstones of Lake Superior," by Dr. Owen himself, in which the subject is discussed and the conclusion arrived at, as he distinctly states, "*after a careful review of all the facts collected by myself and other members of the corps,*"

that this formation is at least as low in the series as the Potsdam sandstone. That Dr. Owen should have ever been led by a more thorough examination of a subject to change a previously expressed, but erroneous opinion, seems to M. Marcou a "*mystery?*" we are justified, then, in believing that this mysterious line of conduct is one which he never intends to adopt, and that the intelligible way of doing things is, having once formed an opinion, to pertinaciously close your eyes to any further light on the subject.

M. Marcou makes one more attempt to sustain his views in regard to the Lake Superior sandstone, by citing those of Dr. Houghton, of whom he says "that his numerous observations on Lake Superior entitle his opinions to be considered with great care." If Dr. Houghton's opinions were to be adopted by geologists, we should have to refer the formation in question to two very different places in the geological series, since he considered all that portion of the sandstone of Lake Superior, *east* of Keweenaw Bay, to "pass under a limerock equivalent of the Trenton limerock of New York," while at the same time maintaining that the conglomerate and sandrocks lying west of Keweenaw Point, were probably contemporaneous with the New Red. That this division of the sandstone of Lake Superior into two distinct groups would not have been maintained by Dr. Houghton in his final report, had he lived to write one, is certain. In the report prepared by Bela Hubbard, Esq., Dr. Houghton's assistant, from the Doctor's notes of survey, made in 1845, and presented to the General Land Office in 1846, the sandstone of Keweenaw Point and the region west of it, is distinctly stated to be the equivalent of the Potsdam sandstone of New York.

Thus Dr. Houghton and Dr. Owen are both seen to stand in the same position, having been forced to change their original opinions on this subject by a more careful and extended examination of the facts. As late as 1843, Dr. Houghton maintained that the "native copper of Lake Superior was of no practical importance," but he afterwards found cause to modify this opinion; and, had he lived to this time, he would undoubtedly have been as little likely to give M. Marcou his support in his theoretical views, as to have denied the practical importance of native copper to the Lake Superior mines. The geologist may, not unfrequently, especially in a new and unexplored region, be led by necessarily hasty and imperfect examinations to form erroneous conclusions; but he will show himself destitute of candor and love of scientific truth, and, as as such, unworthy the name of a man of science, if he persists

in upholding those views, when they have been proved by accumulated evidence to be erroneous, rather than admit that he may have been mistaken.

We have thus met and answered all that M. Marcou brings forward in support of his views of Lake Superior geology. Nothing but the fact that these views have been so extensively circulated, and in a measure indorsed by eminent men in Europe, would have induced us to take up a question which was so entirely settled, and in regard to which there was such an entire unanimity of opinion on this side of the Atlantic. We agree entirely with Prof. Dana, and trust the European geologists will become of the same opinion, as far at least as American geology is concerned, that Mr. Marcou's publications "are not good authority, except with regard to the author and his style of work," a style which we sincerely hope may never become fashionable in this country.

We will conclude this paper by a *résumé* of the evidence furnished by the three surveys which have been carried on in the Lake Superior basin, namely, those under the direction of Sir Wm. Logan, Dr. Owen, and Messrs. Foster and Whitney, as to the age of the sandstone of that region. We are fully justified in maintaining the correctness of four distinct statements, either one of which furnishes ample evidence that M. Marcou's opinions are not tenable, and that this formation is not only not Triassic, but that it is the equivalent of the Potsdam sandstone.

1st. The sandstone of Lake Superior is a formation continuous and identical in lithological character, with the formation or group of strata, shown by the investigation of the geological corps of New York and Canada to form the base of the Palæozoic series in those districts.

2d. The sandstone of Lake Superior is continuous, and identical in character and position with the sandstones of the Upper Mississippi Valley, which the results of the United States and State geological surveys of that region, carried on during ten consecutive years, have amply demonstrated to be at the base of the Palæozoic series of the Northwest.

3d. The sandstone of Lake Superior is characterised by the same form of animal and vegetable life, which, everywhere in this country, as well as abroad, are recognized as being the earliest representatives of organic existence upon the globe. Nowhere within the basin of Lake Superior has a vestige of an organic form been discovered which could, by any possibility, be referred to strata newer than the Palæozoic.

4th. The sandstone of Lake Superior is overlaid in conform-

able sequence, by rocks of Lower Silurian age, as has been shown by carefully measured sections across the Upper Peninsula of Michigan, where the succession of groups is closely analogus to that of the Palæozoic series in New York or Canada. The Lake Superior sandstone, the calciferous sandstone, the Trenton limestone, the Hudson river group, the Niagara limestone, succeed each other in order as we cross the peninsula from north to south, the dip of the strata being to the south, as is fully shown in the natural sections exhibited on the streams which head near Lake Superior and run south into Lake Michigan. There would be no possible means of overcoming the stratigraphical difficulties which would arise if we were obliged to assume that the sandstone strata of the Lake Superior basin were newer, geologically speaking, than the Palæozoic rocks, which form the main portion of the Upper Peninsula of Michigan, in its eastern extension from the Menomonee to the St. Mary's river. There could be no greater absurdity than that of admitting the sandstone of the Menomonee and Escanaba rivers to be of Potsdam age, and at the same time referring the same strata in unbroken continuance, and with identical character, both lithological and palæontological, a few miles farther north, to the Triassic series.

Art. V.—ON THE ESTIMATION OF SILVER.

By Frederick Field.

[*Extracted from the Chemical News, Vol. I, No. 24, and II, No. 29, 1860.*]

The separation of silver by the well known method of cupellation, although almost universally adopted in the examination of minerals and other metallurgic products, has been greatly superseded in the valuation of ingot silver by the excellent process introduced many years ago by M. Gay-Lussac. This method is so familliar to all, and its results are so fully established, as to render any remarks superfluous. It consists essentially of solution of the silver in nitric acid, and precipitation of the metal as chloride, by means of a standard solution of chloride of sodium.

Although excellent in the estimation of silver in ingots, coinage, &c., it is inapplicable in the case of several alloys, and altogether inadmissible in the assay of most minerals. It is a process almost exclusively confined to the Mint or to the sil-

ver refining, and fully answers the purpose for which it was proposed.

In the case of some minerals, it appears very difficult to devise any means for the extraction of the silver by any other method than that commonly known as the dry process. In the chlorides, chlorobromides, and iodides, for example, recourse must be had to the crucible. The two former varieties exist in very large quantities in South America, no inconsiderable portion of the silver imported into England from that continent being derived from these ores. They resist the action of all acids, the only solvents being ammonia and hyposulphite of soda, and although the artificially prepared compounds of chlorine and bromine dissolve in these menstrua, the native minerals require a most prolonged action, and after all the results are far from satisfactory. When it is considered that the loss of one hundredth of a grain of metal in 100 grains of ore is equal to three ounces and a quarter of silver to the ton of mineral, it can easily be conceived that all operations should be simplified and shortened as much as possible, to avoid the liability of the very serious errors which may easily occur.

Were it not for the slight loss of silver which invariably takes place in the process of cupellation, both by absorption in the cupel and by volatilization in the fumes of the lead, the process might be considered as one of the most satisfactory in chemistry, the filtration, as it were, of all impurities, and the residue chemically pure metal, immediately ready for the balance. But many thousand experiments have proved that there *is* a loss, and compensation tables have been constructed, showing very nearly the amount of that loss, giving the quantity of silver which must be added to that obtained, in order to arrive at the truth, and although, independently of the greater or less excess of lead, loss may be partially avoided by the skill of the manipulator, knowledge of the furnace and proper regulation of temperature, the most successful operator cannot altogether avoid the absorption and volatilization which appear to be concomitants of the process.

From some experiments performed in the metallurgic laboratory of the school of mines upon the loss of silver by cupellation, two important facts seem to be fully confirmed, first, "that according to the decrease of the silver cupelled, so the loss of that metal very slightly increases, provided the ratio of lead employed be constant," and second, "that an increasing ratio of lead produces an increasing loss of silver." Mr. Hambly, the author of the experiments referred to, gives us the results of several cupellations in proof of this. For instance,

with regard to the first conclusion, when 25 parts of silver are cupelled with ten times their weight of lead (250 parts) the loss of the former is 1·05 per cent. When ten parts are cupelled with 100, the loss is 1·10 per cent., and with one part to ten 1·20 per cent. With reference to the second conclusion, Mr. Hambly's experiments showed that when the proportions of lead and silver are as 1 to 1, the percentage loss is 0·55; when 10 to 1, 1·52; when 20 to 1, 1·68; and 35 to 1, 1·88 per cent.

These researches were made, however, upon the pure metals, when other metals (as is usually the case) exist in the alloys, the results are somewhat different.

Mr. Napier, of the Mexican Mint, in two very interesting memoirs upon the action of heat on gold and its alloys with copper, and upon deposits in the chimneys of furnaces used for the fusion of the precious metals, communicated to the Chemical Society, (vols. x, and xi,) proves very satisfactorily that on heating an alloy of gold and copper to the fusing point the volatility of the former metal is owing in a great measure to the presence of the copper, and from the analyses of the deposits in the chimneys there can be little doubt that a great part of the silver volatilised was evolved in combination with the same metal. From my own experiments, I am convinced that the presence of copper exercises a most material influence upon the loss of silver in cupellation, and my ideas have been fully confirmed, not only by several French chemists, but by the very extended investigations of M. Domeyko, Professor of Chemistry and Mineralogy in the University of Santiago de Chile.

In the estimation of silver in the double sulphide of that metal with copper the loss is very apparent. Many varieties of these sulphides exist, containing from 20 or even 30 per cent. of silver to one or two tenths of a per cent. Of course the great bulk are of the latter description, those containing from 20 to 50 ounces of silver per ton of mineral. Consisting principally of sulphide of copper, the amount of lead necessary for the cupellation is very large, and contains, after fusion with the mineral, a considerable quantity of copper. The loss of the precious metal was at times so striking as to compel me to abandon the usual method, and to adopt more or less both the wet and the dry process. There is nothing particularly novel in the mode of proceeding, but as very accurate and trustworthy results were obtained it will be briefly described. The finely powdered mineral is dissolved in strong nitric acid until the sulphur is yellow, the solution somewhat largely diluted with

water and one or two drops of hydrochloric acid added. After treating gently and allowing to rest until the supernatant liquid is clear, the residue consists of earthy insoluble matter and chloride of silver. After filtration the filter is dried, and the greater part of its contents mixed in a mortar with carbonate of soda, a small quantity of litharge, and a few grains of bitartrate of potash. About half the mixture is put in a crucible, and the filter is then folded up and placed upon the powder, the remainder of which is now introduced, and the whole covered with a little fused borax. It is preferable to burn the filter in this manner by the heat of the furnace, under a layer of carbonate of soda and litharge, than to consume it by a lamp, and mix the ashes with the flux, as the chloride of silver being so highly volatile some might be lost by the application of the flame, providing no reducing agent were in contact. It may be remarked that many of the native sulphides are difficultly acted upon by nitric acid, and require the stronger energy of aqua regia. I am aware of this, and have tried numerous experiments upon the subject, but have invariably found the use of nitric acid and the subsequent introduction of a very small quantity of hydrochloric acid or chloride of sodium to be preferable.

Chloride of silver is very soluble in hot solution of chloride of copper, a fact easily proved by the precipitate produced by the addition of water to the solution, and even in the cold, traces of silver can be detected. At any rate a long time must elapse before the liquid can be filtered with safety. If, after ebulition and introduction of water, filtration is immediately resorted to, the error in the quantity of silver is of considerable importance. Should the operator be desirous of avoiding cupellation altogether, he can obviate it by the employment of perfectly pure nitric acid, after satisfying himself that no soluble chlorides exist in the mineral, either accidentally or otherwise. Even if this be the case he can extract them by a preliminary digestion in water. In the entire absence of chlorine the whole of the silver is necessarily in solution in the nitric acid, and can be filtered from the matrix, precipitated as chloride, and estimated as such. The plan originally proposed, however, is the safer, as, providing no trace of soluble chloride exist, it is very possible, nay, even probable, that traces of oxychloride of copper (atacamite) may be associated with the sulphide, in which case, after digestion in nitric acid, all the silver will remain with the residue, and will be therefore overlooked.

In metallurgical processes, generally considered, there can

be no doubt that the greatest number of cupellations are effected in those establishments devoted to the extraction of silver from argentiferous galena, and as the native sulphide of lead is associated with comparatively small amounts of copper the errors of the cupel are not augmented by any contingent circumstances. And, moreover, as the silver itself in the large way is obtained by cupellation, the result of the smaller experiment may be regarded as a very fair illustration of the truth, that is to say, the silver derived from a few grains of ore and also from many tons should exactly correspond. M. Mène* has however, in this class of experiments, endeavored to avoid cupellation by adopting the humid process. About 20 grammes of the substance to be analyzed are boiled with nitric acid diluted with three or four times its volume of water. The filtered liquid is precipitated by a considerable excess of ammonia, and then again rapidly filtered. By this means the oxides (lead, &c.) insoluble in ammonia are separated from those soluble in that alkali. The addition of excess of hydrochloric acid to the filtrate throws down the silver as chloride, the other metals remaining in solution. M. Mène gives the result of many experiments proving the accuracy of the method, but when we consider the length of time necessary for thoroughly washing the precipitated oxide of lead, especially if the mineral be rich in that substance, from more than 300 grains of ore, and, moreover, the slight solubility of chloride of silver in chloride of ammonium, which must exist in very large proportion, the advantages of this process over the dry method, I think, are very doubtful. A series of experiments connected with the estimation of silver must be deferred to a future number.

It was remarked in the former paper upon the Determination of Silver that the process originally proposed by M. Gay-Lussac, although excellent in the examination of bullion, could not be adopted in the investigation of silver minerals. About two years ago I was trying a series of experiments, not only upon silver in its various native combinations, but also when it existed as an alloy in coins, ingots, &c. The method adopted was based upon the observation that iodide of starch is immediately decomposed by a solution of any silver salt, and the results obtained were so satisfactory and conclusive that I was preparing a memoir upon the subject, which was only withheld from publication on account of my observing in a new edition Domeyko's *Tratado de Ensayas*, that the idea had been anticipated by M. Pisani, who a short time previously had

* *Comptes-Rendus*, 1857.

been engaged upon the same investigation. The *modus operandi* pursued by that chemist and myself certainly differed in many respects, but the methods were essentially the same. M. Pisani remarks* that iodide of starch, poured into solutions of various salts, is decolorized in some cases, whilst in others it retains its blue color. The decolorization is produced by silver, mercury, and the protosalts of tin, antimony, arsenic, iron, and manganese, as well as the perchloride of gold. The salts of lead and copper have no action upon it. When most of the metals enumerated above are fully oxidized no decolorisation takes place; thus, arsenious acid destroys the color, whilst arsenic acid produces no effect. M. Pisani further asserts that iodide of starch is the most sensitive reagent for detecting silver, providing mercury is not present. Thus it is sufficient to add one-eighth of a cubic centimetre of iodide of starch to 100 cubic centimetres of a liquid containing one-tenth of a milligramme of silver to cause immediate decolorization, although the same quantity of solution gives a very perceptible color to 100 cubic centimetres of pure water. Although protosalts of iron are mentioned by M. Pisani as decolorizers, I observed that the solution of the protosulphate of that metal had very slight action even upon a very weak solution of iodide of starch. In order therefore to estimate the amount of silver in any compound, a standard solution of the iodide of starch was dropped into the solution of the silver compound until the last drop was undecomposed, and caused a blue tint to remain in the liquid. In testing the presence of silver in samples of commercial lead, M. Pisani dissolved the metal in nitric acid, saturated the excess of acid with carbonate of lime, and after cooling added the iodide of starch. Instead of forming a standard solution of this compound, another method was adopted in my experiments. A solution of iodine in iodide of potassium was prepared, and cautiously dropped into the silver salt, to which a little starch-water had been previously added. The silver compound was dissolved in nitric acid, gently evaporated nearly to dryness, a slight excess of carbonate of soda introduced, and the carbonate of silver brought into solution by very weak acetic acid. A few drops of clear starch-water were added, and the ioduretted iodide of potassium dropped from a burette. When the two liquids met a bright blue ring was formed, which immediately disappeared upon agitation, yellow iodide of silver being precipitated. When a permanent blue tinge was produced, no more silver existed in solution.

* *Comptes-Rendus*, Dec. 1856; *Chem. Gaz.* March 2, 1857.

In this process it is not imperatively necessary that all traces of chlorine should be absent. It is better, if possible, to avoid its presence, as the operation then proceeds more rapidly and satisfactorily, but chloride of silver is completely decomposed by iodide of starch, iodide of silver being formed. Thus, if to a liquid rendered opalescent by chloride of silver in a minute state of division, and also containing starch in solution, free iodine be added, a momentary blue color is produced, which gradually disappears as the chloride is becoming converted into the iodide. Nothing can be simpler than this process. The deep blue color in contrast to the pale primrose tint of the iodide of silver being very apparant and striking. Although admitting the excellence of the method of estimating silver by means of chloride of sodium, it certainly appears to me that the sudden formation of a dark color as indicative of the conclusion of the experiment is preferable to the non-appearance of a light white cloud in a colorless solution, as an intimation of the same result. Many trials were made upon the silver coinage of Chile, which is presumed to contain 90 of silver to 10 of copper. The results were in every case most satisfactory. Three burettes were generally employed, in the first one, each division corresponded to one-tenth of a grain of silver, in the second, to one-hundredth, and in the third to one-thousandth. When it was evident that the greater part of the silver had been precipitated by the solution from the first burette, a small quantity from the second was introduced, and the last traces were thrown down by the third.

Many minerals were also experimented upon. No difficulty was experinced in lead ores, nor in the poorer varieties of those of copper; when, however, this metal existed in abundance the solution itself was of so dark a tint that the permanent appearance of the iodide of starch could not be recognized. Tribasic sulpharsenite of silver ($3AgS.AsS_3$) was dissolved in strong nitric acid and the silver estimated most successfully, although the sulphantimonite ($3AgS.SbS_3$) did not give such good results, for if all the antimony be not entirely converted into antimonic acid, the blue color of the starch compound is interfered with. The antimoniate of teroxide of antimony, sometimes called antimonious acid (SbO_4) is generally produced by the action of nitric acid upon antimony and its compounds, and doubtless this is the cause of the occasional fallacies I observed in the estimation of silver when in combination with this metal. On dissolving antimony in nitric acid, evaporating nearly to dryness, and freeing the residue from nitric acid, the white powder gradually but entirely decomposed

a solution of iodide of starch. No difficulty whatever was experienced in compounds of silver and tin.

Mercury, as before stated, entirely vitiates the results, as a salt of this metal decomposes the starch compounds with great facility.

ART VI.—REPORT ON THE CHEROKEE GOLD MINE.

BY WILLIAM P. BLAKE.

TO THE PRESIDENT AND DIRECTORS OF THE CHEROKEE GOLD COMPANY—

Gentlemen : Having, at your request, made myself familiar, by examination, with the condition and characteristics of the Cherokee Gold Mine, I respectfully submit the following Report:

The property, in part, has been known as the *McConnel Mine*, and is about twenty-seven miles from Marietta, Cobb County, Georgia, and twelve miles from Allatoona, on the railroad. These mines are directly in the line of the main Georgia, or Cherokee gold-belt, and are in an elevated and healthy region.

The rocks are chiefly a sandy mica-slate, which, in places, is really a micaceous sandstone or Itacolumite.* This rock forms the bulk of the ridge, and is traversed by many quartz veins, parallel with the bedding, and nearly all auriferous. They are more numerous, and heavier than in the corresponding formation at Dahlonega, and are spread over a width of several hundred yards. They have been mined upon at various points, as shown by old shafts and tunnels; but at present the mining is chiefly confined to Lot 428, upon which, the stamping mill, the whim house, and other mining constructions are located.

The buildings are in a valley near the southeast corner of the lot, and the veins are reached from them by tram-roads, leading to tunnels which radiate from a platform cut into the hill-side, back of the mill, on a level with the stamping floor. These tunnels, and the relative positions of mining shafts and buildings, are shown in the accompanying plot and section.

The ore for the mill, at the time of my examination, was obtained from the main, or McConnel vein, which outcrops

* A rock which bears gold and diamonds, in Brazil, the East Indies, Siberia, and the United States.

on the crest of the ridge, and dips southeastwardly towards the mill. The general course of the outcrop is thirty degrees east of north, and this is probably the direction of the other veins.

In a cross-section of the ridge, westwardly from the mill, we find, *first*, a rich vein intersected by the engine-shaft at a depth of fifty-two feet, from which rich ore has been and can now be taken. This will be referred to as the *eastern vein*. *Second*, a smaller vein cut near the mouth of one of the tunnels. *Third*, one or possibly two veins cut at the ends of the two tunnels on the north side of the mill. *Fourth*, we reach the main or McConnel vein, though it is possible there are intermediate veins worthy of exploration. West of this vein the ground is not developed by the openings, but, as we pass over the ridge, on the surface, a little further south, we come to another large vein, which has been extensively mined, and has furnished a large amount of gold. This is known as the *Williamson vein*, and is mainly upon Lot 437, adjoining the other. Between the two last described veins there is an outcrop of compact, hard, sandy, mica slate, or micaceous sandstone. The whole surface of the ridge above this Williamson vein is covered with the debris of quartz veins, so that it is difficult to say how many there really are; but it is probable that there are many more than those enumerated. The principal veins will now be described in succession.

UPPER, OR McCONNEL VEIN.

Entering the main tunnel on a level with the mill, we reach the vein in a distance of 260 feet, and can then follow upon it along a gallery for a hundred and ten feet. Its width varies from five to fourteen feet or more, and is composed of a peculiar slaty quartz, or quartz divided into seams and thin layers by films of mica. In some places iron pyrites abounds, and there the vein is rich in gold. Pyrites, however, is more or less disseminated throughout the larger part of the vein, its presence being indicated in the upper part of the vein by the rusted condition of the quartz. In the level, thirty feet above the lower tunnel, the vein at one point is fourteen feet wide, though the wall rock is discolored and contains more or less quartz in seams for a much greater width, but has not been found available for gold.

At the northern end of this upper level, Captain Mager is now sinking a winze on the vein, in the bottom of which a width of ten feet of the vein is exposed above the foot wall, the hanging wall not having been reached. Ore from this winze

was being crushed in the mill at the time of my examination, and I made some trials of it by pounding and panning with satisfactory results. The vein at this point looks well, and appears to be growing more pyritic, and, consequently, according to the experience of those working the vein, is richer in gold.

This ore can be mined very cheaply, as the foot wall consists of a peculiar decomposed slate, very white and silicious, appparently a fine-grained sandstone or Itacolumite, which may be broken out by the hand alone. Captain Mager states that in some places this is from six to ten feet thick. When a portion of this is removed, the overlying vein-stone is readily thrown down, its slaty structure facilitating the operation.

The greater part of the ore stamped by McConnel and others was taken from that part of the vein immediately above the winze, and between it and the end of the tunnel. This part of the vein, about fourteen feet wide, has nearly all been removed above the level of the tunnel, and in some places for several feet below. The excavation is secured by a double line of timbers. It thus appears that the available ore in this part of the vein is now contained between the two levels, giving from the lower level to the other about forty feet of "backs." The quantity of stoping ground may, however, be continually increased by driving the galleries further upon the course of the vein. I would here observe, however, that I do not regard the ore as uniformly auriferous along the whole course of the vein. The richest portion probably extends downwards on the dip of the vein in a broad "shoot" with a northerly inclination. The vein, however, has been opened and mined successfully at various points for a long distance upon the surface, showing that if the best ore is in shoots, there are several of them, all of which may be developed by judicious exploration.

EASTERN VEIN.

This vein was first cut at the surface in excavating for the platform, and is now reached by two shafts at depths of forty-two and fifty-two feet respectively. From one of these shafts a level has been extended on the course of the vein about twenty feet to the northeast. The ore from this level presents a good appearance, and pans extremely well. It is a porous quartz, charged with iron pyrites in abundance. This vein is said to be about six feet wide, and is stoped out for twenty feet above the level, and gives promise of a large amount of rich ore. This shaft and level are drained by the pump, and Cap-

tain Mager intends to sink upon the slope or dip of the vein and drive levels, so as to thoroughly open the ground. It is probable that a rich shoot of ore has been struck here, and that it may be followed downwards for a long distance.

MIDDLE VEIN.

I thus designate the vein cut in the tunnel near the north end of the mill. It is probably the same as that which was formerly worked on the surface from the hill side. A considerable amount of ore has been taken out in a slight depth, and the vein will probably afford a large amount of good ore, if systematically worked.

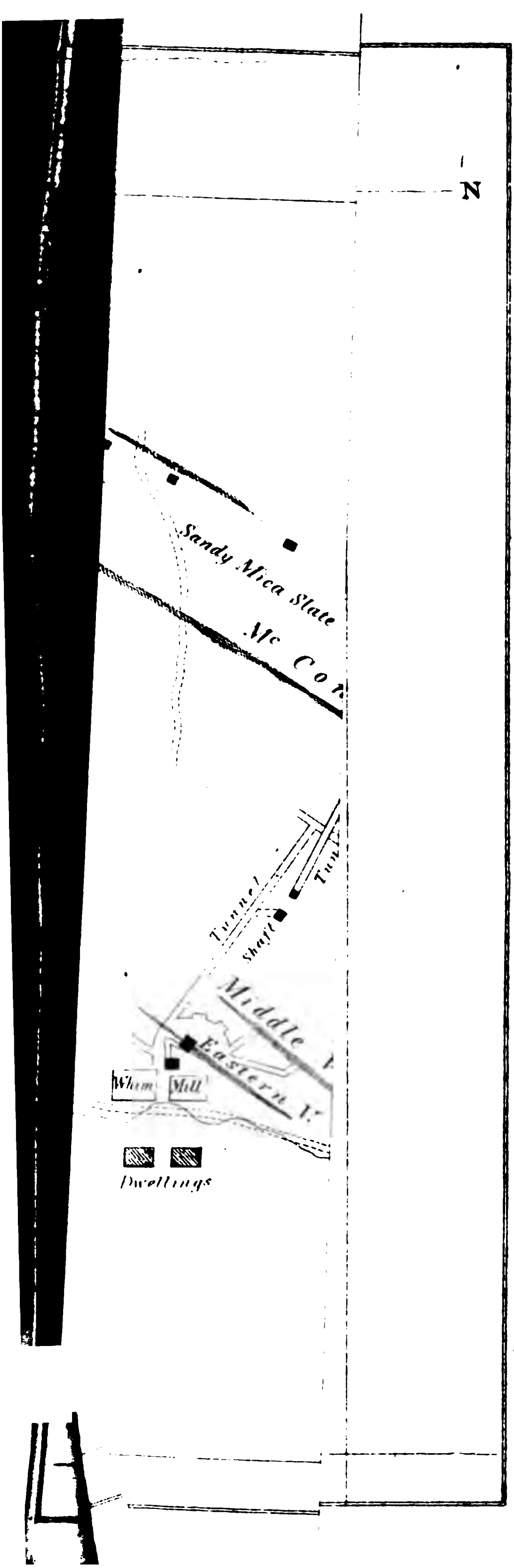
WILLIAMSON VEIN.

This vein outcrops on the opposite side of the ridge and dips under all the others, as shown in the transverse sketch section. It is celebrated for the richness of the ore, a large amount having been taken out worth fourteen dollars a bushel. This mine has not been opened or worked for several years, though ore as good as any ever obtained is still left in the bottom of the excavations. This vein was worked seventy five feet from the surface, being unwatered, or drained at a depth of about fifty feet by an adit about three hundred feet long, extending from the vein to a little rivulet in the hollow or valley. The water below this adit, to the depth of twenty-five feet, was lifted by pumps or buckets, but no effective machinery was employed. The vein appears to have been the richest near where the adit reaches it. There are, however, many shafts sunk above the outcrops, along a distance of four or five hundred feet. I procured several small fragments of the ore from the vein-washed surface of one of the old heaps, and found them to consist mainly of oxyd of iron; less than a gill of their powder gave a large show of gold when washed in a pan, enough to satisfy me that its richness had not been overstated. There is no doubt that quantities of ore may be obtained from this vein by sinking and driving. It would be necessary to erect pumps for drainage.

THE MILL AND THE GOLD.

A mill of twelve stamps is in operation upon the property. The shaft is a hollow cylinder of cast iron upon which the cams are securely keyed. The mill is driven and the pumps worked by a twelve horse steam engine, requiring about eight cords of wood a week, or about fifteen when running night and day.

In the eighteen days work preceding my visit, eight hundred


N
Sandy Mica Slate
Tunnel
Shaft
Middle
Whim
Mill
Dwellings

and twenty-seven pennyweights of gold in the "quick," or about four pounds, were obtained. Inferior ore had been crushed during a part of the time.

The gold of these veins is said to be worth a fraction over a dollar a pennyweight, being very pure and of a rich yellow color. In the various trials of the ores by panning, I found that the gold was in small angular grains, a part of it fine, but heavy, and not difficult to save.

The little branch leading past the mill into which the tailings are now run has afforded much gold, and has been worked over as a deposit mine, three or four times profitably. The largest piece of gold found in this deposit, weighed nineteen pennyweights.

I have indicated by broken lines on the sections, the manner in which the shafts may be sunk, and levels driven, so as to secure a good and constant supply of ore. If the ground is soft in the engine shaft, it will be best to sink it deeper, as indicated, but if hard, and expensive to break, sinking on the vein is preferable.

Art. VII.—REPORT ON THE HENDRICKS GOLD LOTS, LUMPKIN COUNTY, GEORGIA.—By William P. Blake.

To the Trustees of the Auraria Mines.

Gentlemen: During my recent visit to the Gold region of Lumpkin County, Georgia, I examined for you the three lots known as the "Hendricks Lots," about one mile from Auraria, and six from Dahlonega. These lots are Nos. 602, 659 and 672, each containing forty acres, and lying side by side in an east and west range, taking in the valley of Station Branch from its mouth to its head. Lot 602 is also traversed by Camp Creek, in a north and south direction, as may be seen by referring to the map of the lots which accompanies this report.

Having previously spent much time in exploring and reporting upon that region, I was able to complete the examination in a manner satisfactory to myself in a much shorter time than would otherwise have been required.

The property is within the upper edge of the principal Gold Belt of Georgia, and in a central position with respect to the mines. A portion of it was formerly occupied by the United States troops, who were stationed there to protect the Indians from the intrusion of the miners soon after the discovery of

the gold. It is also noted, not only for the richness of its gold deposits along the branches and creek, but for its hill deposits and rich vein.

The valley of Camp Creek is low, and the ground rises from that stream to the crest of the ridge, or divide, on lot 702, from which the surface slopes away in the opposite direction to Ralston's Branch. This upper lot is traversed along the ridge by the Dahlonega road from north to south, and it is directly in the line of prolongation of the celebrated group of gold veins forming the Pigeon Roost streak. The Castlebury lot, No. 728, on which so many rich veins have been followed, adjoins lot 672, the two cornering together, and the same veins are presumed to be common to both lots. One vein, at least, has been recognized and mined upon on the Hendricks lot to a considerable extent with profit. This is the chief vein of the property, as far as now known, and is generally called the *Hendricks Vein.*

HENDRICKS VEIN.

The directions or trend of this vein is about twenty degrees east of north, and its line of outcrop is shown on the map by the dark line, which is curved, owing to the irregularity of the surface, while the true direction on a level as nearly as could be ascertained, is indicated by the straight dotted line. The outcrop follows the crest of the ridge, very nearly, and is by estimate, two hundred feet or more above Camp Creek, half a mile distant. The dip or pitch of the vein is to the southeast at an angle of about forty degrees. It has been opened and worked along the whole length of the outcrop; shafts having been sunk at short intervals and levels driven, but the excavations are not deep, few if any of them extending below water, or about fifty feet. They are mostly upon the dip of the vein, it having been followed downward from the surface. The ore was taken out by several different persons at different times, and was carted a considerable distance to be crushed. All who have worked on the vein say that it was rich. Mr. Finley, who mined there for some time, says that the vein is two feet thick, and that the ore paid from 90 cents to $1.05 a bushel. Ore of this richness does not extend throughout the whole vein, though there are portions that are much richer.

This vein is the continuation of the celebrated Pigeon Roost Streak of veins and doubtless has similar characteristics. The lot adjoins that of Castlebury's, from which a large amount of gold has been dug from veins, and which is at the head of

Pigeon Roost Hollow, or the open cut in the soft slate. If any additional evidence of the continuity of this group of veins through the Hendricks lot were wanting, it is found in the fact that similar veins are found beyond to the southwest, in the same line, and have afforded similar ore of great value.

It is proposed to work this vein by tunnels run in either upon its course or across the strata to intersect it, a point being chosen where the distance is least, and the ground most favorable. The best point is near the head of Station Branch, where the ground is low, and the entrance, and the point of delivery of the ore would be towards the mill, about to be erected. A tunnel might be carried in from the east side, on the slope towards Ralston's Branch, which is quite abrupt, and has the advantage of being nearer to the vein, which dips in that direction. A tunnel at the west side, towards the mill, would also have the advantage of exploring the ground for a considerable distance where one or more veins are supposed to exist, for outcrops are found on the surface. On the other hand, there are good reasons for not cutting a tunnel, and for sinking a shaft instead. A favorable point being chosen, a shaft may be sunk at once upon the incline of the vein, and pumps erected to drain it to any depth as the work progresses. A tunnel, at best, will not gain more than sixty feet of new ground for backs, unless it is made very long and at great cost—greater than that of pumps and fixtures, by the aid of which the mine may be carried to a great depth. A shaft can be very rapidly sunk on the vein, and when sixty feet or so of depth below the old levels or shafts is obtained, levels should be extended on the vein, each way, to prove the ground and find the shoots of ore which may afterwards be stoped out to the old workings above. In this way all the labor will be expended upon the vein, and the ore which would be obtained in the shafts and tunnels should more than pay the expenses of sinking and driving. If a tunnel were driven, it would ultimately be necessary to open an engine shaft from the surface down, so as to erect pumps to the best advantage. I therefore recommend sinking upon the vein, and the abandonment of the plan of driving a tunnel or adit.

UNEXPLORED VEINS.

There are other veins upon the property which have not been much explored, and there are doubtless some not yet discovered.

A small one has been cut near the head of Keys Branch,

which affords very rich ore. It is a thin vein following the slates, and from its position would appear to have been one of the sources of gold in the ravine below. It is exposed for a short distance only, but it may prove to be worth exploring to a considerable depth and lead to a valuable body of ore. There are several other small veins in that vicinity which have not been much explored.

Rich ore, from their veins, has also been found at two or more points along the Dahlonega road to the westward of the main vein.

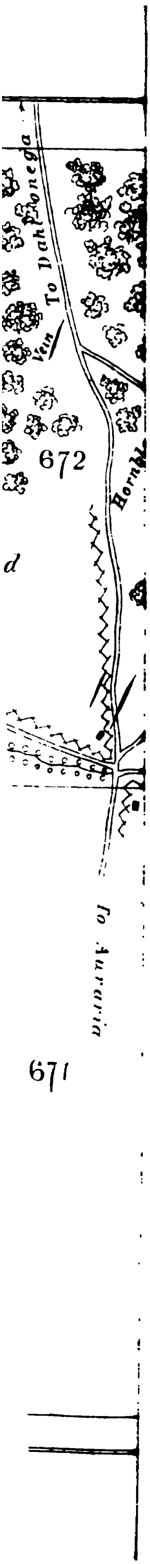
STREAM DEPOSITS.

The chief stream deposit of gold is that along the sides of Camp Creek, on lot 602, where there is a broad flat, underlaid with auriferous gravel. This is a rich deposit, and has been considerably worked, yielding on an average for several acres as much as ten pennyweights of gold for every pit ten feet square. This yield has been calculated upon with great certainty for several years, and Mr. Hendricks was accustomed to place his laborers there each year between harvesting and planting, and could calculate with more certainty upon his crop of gold than upon his corn.

Many acres remain to be worked, but the ground is too low and flat to be successfully washed out with the pipes, unless some way of obtaining the necessary fall or grade for the tailings is found.

The deposit along Station Branch is also extensive and rich, and is probably of greater value than that of Camp Creek, for the greater part may be washed out with the pipes. It was well known among the miners formerly, as a very rich valley, and was a continuous gold deposit, from its mouth in Camp Creek to the head spring, and beyond it up to the roadway. Owing to the want of sufficient water, the upper portion of this deposit has not been thoroughly worked, and in this ground horse-washing would be peculiarly effective and profitable. The greater part of the gold in this valley was doubtless derived from the Hendricks vein and those near it. There is an abundance of quartz gravel along the valley, showing the great amount of denudation the veins have suffered.

Keys Branch is another important steam deposit. It empties into Camp Creek a short distance above Station Branch, and was found to be very rich in gold. A very large amount of auriferous gravel is found here, and it may all be regarded as profitable ground for pipes or sluice washing.


To Dahlonega
Vein
672
d
To Auraria
671

HILL DEPOSITS.

Good hill deposits, or beds of auriferous gravel above the present levels of the streams, are found on either side of Station Branch, especially at the north side towards the mouth. They are also found along Camp Creek, and on the point of the hill between Keys Branch and Station Branch. These hill deposits have been but slightly worked, and are believed to be about as rich as the deposit along Camp Creek. They are very well situated for washing, and a large part of them are below the line of a ditch for which a survey has been made.

New Haven, June 9th, 1860.

Art. VIII.—REPORT UPON THE PROPERTY OF THE VALLEY RIVER GOLD COMPANY.—By William P. Blake.

To The Trustees of the Valley River Gold Company:

Gentlemen: I have visited the "Parker property" on Valley River, Cherokee County, N. C., and examined it with reference to its richness in gold, and its adaption to Hydraulic Hose Mining.

The valley is in the extreme southwestern corner of North Carolina, and is most readily accessible from Cleveland, Tennessee,—from which it is distant seventy miles,—and from Dahlonega, or other points in Upper Georgia. Murphy, the County-seat, is at the lower end of the valley, at the junction of Valley River with the Hiwassee, and the mines under consideration are about twelve miles above.

This valley has many points of interest, being remarkable alike for its varied and beautiful scenery, and its agricultural and mineral resources. Historically, it is noted as the favorite home of the Cherokees, and former tribes, and as the scene of some of the earliest mining adventures on this continent. Looking below the surface to the rocky frame-work, we find beds of mica slate, layers of metamorphic sandstone, and ledges of white limestone, or marble, associated with steatite. Gold-bearing veins appear at several points, and have given rise to rich deposits of gravel.

The Parker property consists, as I am informed by Mr. Parker, of three hundred acres of land, extending from the east bank of Valley River, back to near the top of the mountain ridge bounding the valley. It thus includes the mountain slope, and is traversed by three brooks or "branches," which so cut the slope with their valleys that four principal ridges or spurs from the main ridge are formed. The rocks of these ridges are chiefly mica-slate, charged in places with large crystals of staurotide. The marble is in the valley beyond the limits of the tract. Quartz ledges out-crop at various points along the base of the main ridge, and are believed to be the source of the gold which is found on the property.

HILL DEPOSITS.

The beds of the branches were roughly and rapidly worked for gold several years ago, and were found to be very rich. Gold was also discovered above the level of the branches on each side, and one of these ridges between Parker branch and Parsons branch (see the sketch map appended) was found to be a hill deposit, or high placer, of uncommon value, and has been more or less worked from the time of discovery until now. Wherever an excavation has been made on this ridge a heavy accumulation of river-drift or water-worn boulders and gravel has been found. Coarse water-worn fragments of gold are found with it, being spread through the lower layer of the drift, and imbedded in the yielding surface of the mica-slate or bed-rock. This drift deposit is very thick, and both the boulders and the gold are unusually coarse and heavy for the deposits of the Atlantic gold-field; though nearly identical in appearance with the coarse hill deposits of California. The boulders are almost without exception of quartz, and many of them exceed fifteen to eighteen inches in diameter, and eighteen to twenty-four inches in length. Even these are much worn, as if drifted for a long distance, though they were probably broken out from ledges in the main ridge not half a mile distant.

This hill-deposit has been noted for its richness, and a considerable amount of the pay-gravel has been carted from it to water, and washed with profit. The ground has been torn up in various places over the hill, and washed in toms where water could be had. In this way much of the gold was left behind adhering to the surfaces of the larger boulders; and it is the general belief that even the old piles of gravel will pay to be rewashed by the hydraulic method and sluicing. A large extent of the ground remains undisturbed, which will yield

largely when washed with the thoroughness and rapidity which attends the hydraulic process.

I tried some of the new gravel by panning, and obtained a large particle, about the size of a grain of wheat, in the first pan. Where gold is so coarse, it generally takes several pans of dirt to show the color, unless the streak is extremely rich. Of this ground remaining unwashed, I estimate that there is about thirty acres on this, and the two ridges and spurs adjoining. The whole is most favorably situated for washing with the pipes or sluicing; the surface sloping towards the river, and on each side toward the branches. The main streak or layer of the gold and gravel, is along the top of the hill, where the slate "pitches in" from each side, so as to form a shallow trough. This configuration of the ridge will allow of the simultaneous use of many pipes without interference, and of the rapid escape of the tailings. The depth of the gravel and soil, from the surface to the bed-rock, is not great, varying from two feet to six or eight, and is rarely deeper. The upper portion, or the sand and clay, has a deep red color; is not tenacious and tough, but can be readily broken up and diffused in water.

This deposit has paid Mr. Parker, as I am informed, from four to six pennyweights a day, with two hands and a little stream of water sufficient for a tom.

STREAM DEPOSITS.

Rich gold deposits are also found along each of the branches or brooks on the property. Parker's branch, the most northern, has a very favorable looking deposit near the head, where the valley is expanded and was very rich, but never was thoroughly worked. The grit in this deposit is coarse and heavy, like that on the adjoining ridge above, and bears coarse gold. In this expanded, flat portion of the gold deposit, the fall or descent of the branch is slight—less than is desirable for piping or sluicing; but it is very good a short distance below, and still further down, or about one hundred and fifty yards from the flat, there is a shoal or fall of several feet, caused by a narrow bar of rock, which might be easily cut out so as to obtain all the descent or fall necessary to the thorough washing out of the deposit above.

By careful inquiry of Mr. Parker, who formerly worked in this deposit, I ascertained that the ground was considered good, on an average, for two pennyweights a day to the hand, working as they did at that time, by pitting off and washing

in rockers. There was but little clay in the deposit, and that was easily dissipated in the water, so that the rapid and thorough washing out of this flat may be safely calculated upon. It was worked very irregularly and imperfectly, much of the ground being left, in the haste to get at the best places, by rival parties of men. The work has been extended laterally from the deposit to the hill-side, in several places, enough to show that the gold is very generally distributed, and in paying quantity, on the hill-side along the branch.

The next valley, or *Parson's branch*, is longer, and the most important stream gold deposit on the tract. This brook heads high up in the main ridge, and flows along the southern slope of the chief hill deposit. It bears gold the whole distance from its mouth to within a short distance of its head, as indicated on the map. The gravel of this deposit is heavy and abundant, and has been torn up considerably by miners, though a considerable area of fresh ground remains. At the extreme lower part of its course the deposit was very rich; but this part is probably too low and flat to be piped successfully. By starting the washing at the point of junction with the third branch, it is believed that the whole deposit above that may be successfully washed out. The paying streak is not confined to the bed of the branch alone, but spreads out over a considerable surface; cuts across the points of the ridges, and extends up their slopes so as to form low hill deposits. The valley narrows toward the upper part, but is probably good ground for the pipes and sluice to the upper limit of the gold.

The next, or most southern of the branches, unites with Parson's branch near the foot of the ridge, and is about a quarter of a mile in length. It bears gold the whole distance, but for the lower half of its course the valley is narrow, and this part would not be profitable ground to wash out with pipes. At the upper end, however, the deposit expands, and is very rich in gold. Where the valley is so narrow the fall is rapid, and by cutting out a channel so as to drain the basin-like deposit above, it is probable that the whole basin might be profitably washed out. The slate is hard, and it will require blasting.

Beyond this branch, and further south, on the opposite side of the ridge, we find another valley, extending southerly, of which, the upper portion only, or about two hundred yards, is upon the property; the lower and the largest part being upon the Courtenay gold lot, of which, I understand, you have

a lease for working. This deposit extends to Valley river, and is reputed to be rich in gold.

VEINS.

Although this property is so rich in placer-gold, no vein which can be identified as the source of the metal, has yet been found. The fact that the branches were rich in gold, up to a certain point in a line with a ledge of granular quartz, which shows at intervals along the ridges, indicates this as the source of the gold, but no gold can be found in this vein, at any of the places yet examined. On the ridge where the hill gravel has been washed, two small veins have been found, near together. These have been traced for a few yards only, and they cut directly across the stratification of the state, being, to all appearance, true fissure veins, showing interlacing crystals of quartz, and layers of pyrites. The upper portions of these veins are decomposed, and stained by iron-rust, and when pounded and panned, give a very good show of gold. These veins are rich, and when they have been traced for a greater distance, so as to show conclusively the presence of a great body of ore, they will justify preparations for mining and crushing. Another vein is said to have been cut in the washings at the upper end of the Parker branch, but it was not uncovered during my visit. From the fact that I saw other gold veins, narrow but rich, on the opposite side of the valley, I conclude that they are not unfrequent in that section.

AQUEDUCT.

This property should be worked as a *placer* gold mine alone, at least for the present, or until some valuable veins are discovered, which may happen during the progress of the washing operations.

A survey of a route for an aqueduct to supply water to these placers has been made for Col. Kelley, who reports that an abundance of water for ten pipes, of one inch nozzle and sixty feet head, can be had by bringing the water of Vengeance Creek, from the opposite side of the main ridge, through a gap, where a tunnel 700 feet in length will be required. This would deliver the water at a great elevation above the ground to be washed, which is important, for, in the present improved condition of hydraulic hose-mining in California, it is found to be highly advantageous to use pipes of greater size than formerly, and to work with a head or pressure of 150 to 200 feet instead of from 60 to 100. To sustain this great pres-

sure, pipes of boiler iron are employed to take the water from the penstocks to the mine.

The water of Taylor's Creek, on the same side as the mine, may, perhaps, be brought to bear upon the hill deposit and all of the mining ground at the necessary elevation, and would funish water sufficient for ten pipes. The property is so situated that this number of pipes could be placed in effective operation at once. All the branches empty into Valley river, which runs with a swift current, and in large volume, so that the tailings from the washings will be rapidly carried off, out of the way, as soon as they reach the river.

As you have requested me to state my opinion as to the probable yield per day to each pipe, I observe in conclusion, that it will vary greatly with the position and character of the ground. The trials I made of the fresh ground of the hill deposit, and the results of the previous day's washing by two men, using a tom, justify the opinion that such ground would not yield less than ten dollars a day to the pipe. There is doubtless ground yet unworked which will be found to yield much more than this, while some will not pay over five dollars, but even at this comparatively low yield the margin of profit per pipe would be ample.

New Haven, Conn., May, 1860.

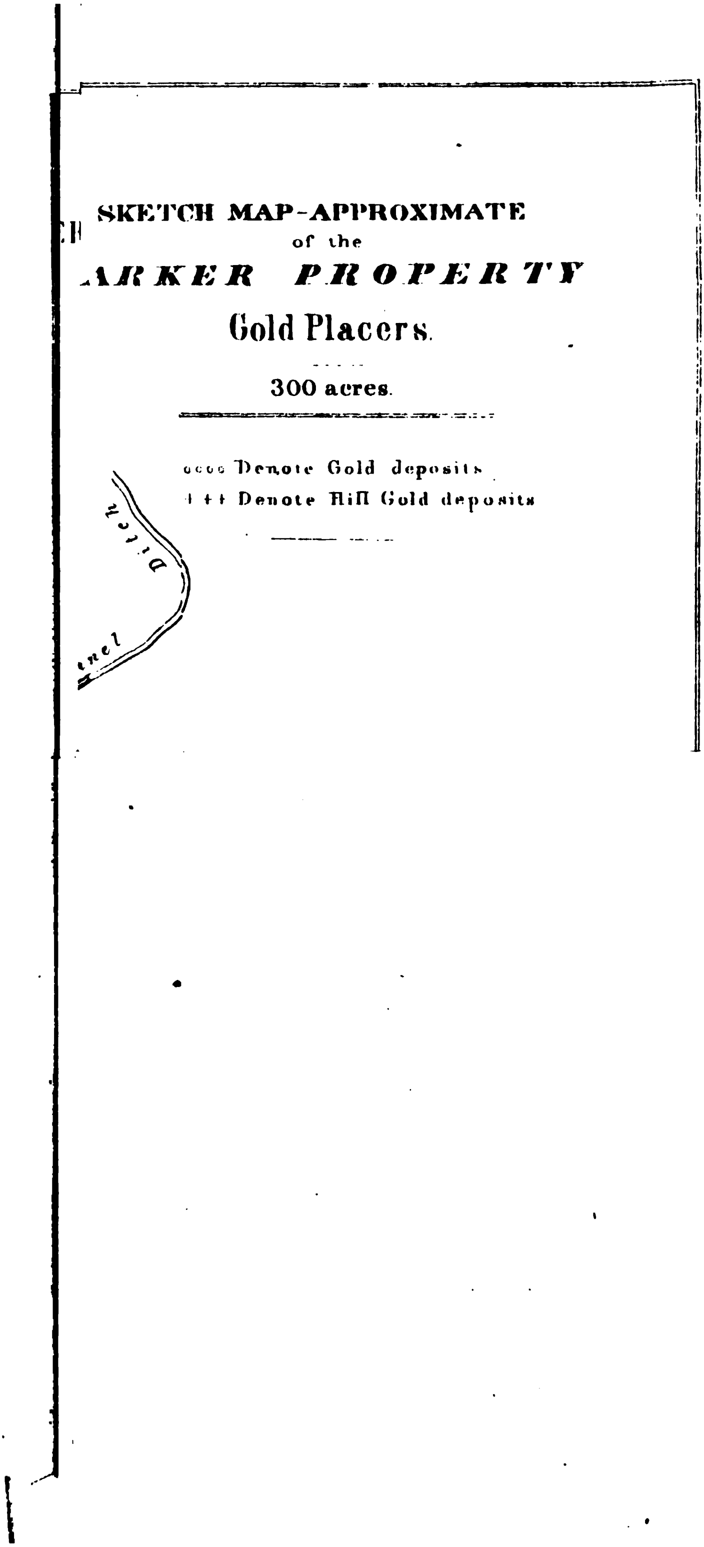
ART. IX.—DR. CHARLES T. JACKSON ON TETRADYMITE AND BORNITE.—REPLY TO DR. F. A. GENTH.

Boston, March 30th, 1860.

William P. Blake, Esq., Editor of Mining Magazine:

My Dear Sir,—I am sorry to have to differ with any of my professional brethren, but feel called upon to notice some remarks made in the last number of the Mining Magazine, on one of my analyses by Dr. F. A. Genth of Philadelphia. Although I have not the honor of a personal acquaintance with Dr. Genth, I know something of his scientific standing, having read many of his publications in the American Journal of Science.

I regret that he should have denounced the methods of analysis laid down by so high an authority in analytic chemistry as Professor H. Rose of Berlin, for the methods adopted by me were hose of that illustrious chemist, and were carefully executed.


SKETCH MAP-APPROXIMATE
of the
ARKER PROPERTY
Gold Placers.
300 acres.
oooo Denote Gold deposits
+++ Denote Rill Gold deposits
Ditch
nel

Whether there may be other and better methods of operating is of little consequence in this case, since the methods adopted by me were those by which the original species Tetradymite and Bornite were established, and were those by which I first determined these two rare minerals in the United States, having, in April, 1850,* published my original analysis of the Virginia Tetradymite, and in March, 1859, the Bornite of Dahlonega, Georgia.

It is possible that Dr. Genth may have analyzed a different mineral from the one which was the subject of my paper in the American Journal of Science, May, 1859, pp. 366, 367.

It is certain, from his analysis, that his specimen was quite impure, and a mixture of minerals, as shown by his results.

My analysis was made on a very pure crystallized specimen, which was carefully selected and inspected by aid of the microscope, previous to its solution. The specific gravity of the Virginia Tetradymite was 7·4685, while that of the Georgia Bornite was 7·8680.

The aspect of the two minerals is quite different, the Virginia mineral having a much lighter color, more like that of lead, while the Georgia mineral is darker, and of the color of highly polished steel. Therefore their physical characters are quite different.

In the analysis, the same methods were employed on the Virginia Tetradymite and the Georgia Bornite, and yet the results were so different as to establish the two species beyond dispute. I have the ox. bismuth and the metallic tellurium obtained from the Georgia mineral now before me, sealed up in glass tubes, and they are known to be pure, having been duly tested to ascertain the fact.

The analysis of the two minerals stands thus:

Tetradymite of Virginia. SPE. GRAV.=7·4685.		*Bornite of Georgia.* SPE. GRAV.=7·8680.	
Bismuth	58·80	———	79·08
Tellurium	35·05	———	18·00
Sulphur	3·65	Selenium	1·18
Gold, iron and silica	2·70	Gold	0·60
		Loss	1·14
	100.20		100·00

* I first discovered tellurium in the Tetradymite of Virginia, May 24th, 1848, the specimens having been given me by the late Knowles Taylor, Esq., of New York, May 6th, 1848. I published the fact in American Journal of Science, new series, vol. vi. p. 188, in June, 1848.

My re-examination of this mineral, in which its full composition was made out, took place April 15th, 1850, and was published at the time in American Journal of Science and in Dana's Mineralogy.—C. T. J.

The tellurium was separated by means of sulphite of ammonia, and a current of sulphurous acid gas, long continued, and the whole was allowed to stand in a beaker glass, covered, and in a sand bath, at a moderate temperature, until all the tellurium subsided in its metallic state.

The selenium was determined as seleniate of baryta, on a separate gramme of the mineral, and its nature was tested by means of the blow-pipe, and the absence of sulphur was proved.

Perhaps my letter to the editors of the American Journal of Science did not state my operations in sufficient detail, and hence Dr. Genth may not have been aware of the whole extent of my researches. I have little doubt of the existence of variable mixtures of metals in the minerals known as Tetradymite and Bornite. Dufrenoy says, "We may conclude that there exists three different species. We think it preferable to suppose that these are alloys of Bornite and native bismuth." If such is the case, we should not be surprised at the different results of chemical analyses, and I would suggest that great care should be taken in the selection of specimens for such analyses as are to go into the records of mineralogy, as establishing species.

I shall not notice some few inaccuracies in Dr. Genth's quotations of my publications, for I doubt not they were accidental and unintentional on his part.

Respectfully, your obdt. servant,

CHARLES T. JACKSON, M.D.

SCIENTIFIC AND MINING INTELLIGENCE.

GEOLOGY.

Geological Survey of California.—The Legislature of California, at its recent session, passed an "Act to create the office of State Geologist, and define the duties thereof." The name of Prof. J. D. Whitney was inserted in the bill as the appointee. The sum of $20,000 is provided for the expenses and outfit of the survey, and $6,000 a year for

Prof. Whitney, who will appoint assistants at such salaries as may be decided upon by the Governor and himself.

The announcement of the introduction and passage of this Act took those who have been identified with the progress of geological investigations on the Pacific slopes, completely by surprise. Mr. Whitney's name being included in the bill, applications for the appointment from others could not be considered by the Governor.

Geological Survey of Tennessee.—Liberal provision has been made for the publication of the final report of the Geological Survey of Tennessee, which, it is said, will make an octavo volume of four or five hundred pages, and will be accompanied with a carefully executed Map of the State. It will probably be published next Spring. The Survey is suspended for the want of appropriations by the Legislature.

Prof. W. B. Rogers on the Deposition of strata during subsidence.—Proc. Bost. Soc. Nat. Hist. March, 1860.—Prof. W. B. Rogers explained his views of the stratigraphical relations of deposits formed in an ocean, under each of the three conditions of a *stationary*, a *subsiding*, and a *rising* position of the sea-bottom, illustrating the several results by drawings on the blackboard.

In the first and second of the conditions here named, the level of the resulting land would be *approximately horizontal ;* while in the third case, that of the uplifting of the ocean-floor during the accumulation of the deposits, the surface would present a slope descending from the oldest deposits on the first shore-line to the strata latest formed ; in other words, the *older deposits* would crop out at the *higher level*, and the successively later ones at a less and less elevation.

The Appalachian strata embraced between Lake Ontario and the Pennsylvania coal region present a relation of levels *the reverse of that last named*, the older strata cropping out at successively lower levels as we proceed northward, while the newer formations, the Devonian and Carboniferous rocks on the south, are piled up to a height of some thousands of feet above the level of these outcrops. For this and other reasons, Prof. Rogers could not admit the theory which regarded the present stratigraphical features of this region as evidence of a deposition of the strata during a long-continued upward movement of the ancient sea-floor.

Another consideration opposed to this view is the *great aggregate thickness* of the marine deposits exhibited in the middle and southern portion of the Appalachian area, and the known fact that even the older and lower of these formations, where brought to view by anticlinal struc-

tures, present a composition and surface-markings bespeaking a comparatively shallow ocean at the time of their accumulation. As, therefore, the ancient sea of this region could have had no great depth at the commencement of these deposits, it seems clear that, in order to receive the whole series of more than twenty thousand feet of successive strata, its original floor, instead of rising during this period, must have undergone *an enormous amount of depression.*

Looking to the series of carboniferous rocks forming the upper portion of this vast succession of deposits in our Appalachian basin, the evidences of such a subsiding movement are too obvious to be questioned. Each of the nearly horizontal beds of vegetable matter forming an incipient coal-seam must have been deposited at or a little above the ancient sea-level, and must then have been depressed and covered in by sediments forming the sandstones and shales, often with marine fossils, which now overlie it. Thus, stage by stage, with long pauses, in which the materials of successively newer coal-seams were accumulating by vegetable growth, the sea-bed was depressed until it had received the entire thickness of the carboniferous rocks, with their included strata of coal.

On either hypothesis, that of a subsiding or of a rising ocean-bottom, the features of the land, as first presented on the completion of its formation, would be far from corresponding with its present topography. This existing configuration has undoubtedly been the work of subsequent denudation, of which extensive and unmistakable evidences are apparent throughout the paleozoic area. The theory of an unlifting movement during the deposition does not, as has been supposed, dispense with the necessity of such a further agency for remodeling the surface. On the contrary, in this case, the depth of denudation required to carve out the profile of the region in question, so as to make it conform to the existing features, would be far greater than would be needed to bring the imaginary subsidence-area to a like agreement. In the latter conditions, the denuding force would be called on to remove only a certain amount of material below the horizontal surface over the northern portion of the tract; in the former, it would have first to cut down the greatly elevated out-crops at the north to bring them on a level with the southern deposits, and after this to do an additional amount of excavation equal to that of the other surface.

Admitting the validity of these arguments drawn from obvious mechanical and stratigraphical relations, we must conclude that the remarkable preservation of the paleozoic strata in the region referred to

has been due to the subsidence which successively removed them in great part from the destructive effect of shore-action, sealing them down under an accumulation of overlying deposits. This preservation, therefore, is entirely consistent with the view of Darwin and other geologists, of the extensive destruction of deposits with their fossils, when, through an *uprising movement*, they are brought, stratum by stratum, within reach of the wasting and dispersing forces of the shore. It certainly affords no argument in contravention of that doctrine.

In maintaining that these paleozoic rocks were accumulated during a period characterized, on the whole, by a great aggregate subsidence of the ocean-floor, Prof. Rogers was far from supposing this movement to have been regular, or without pauses and reversals. He believed that the materials of the successive great formations bear intrinsic evidence of repeated *long pauses*, and that the transitional deposits are marked by the proofs of occasional, and perhaps frequent, *upward oscillation*. During these subordinate pauses and upward movements, themselves occupying periods of great absolute length, however small in comparison with the whole, we may well conceive that many extensive sheets of the previous deposits were disintegrated and dispersed, and we may fairly infer that the existing series of strata, with all their seeming fulness, are but an imperfect and fragmentary record of the life-history with which they are impressed.

Prof. Agassiz maintained that there was not subsidence during the deposition of the New York strata, and that the facts do not indicate it, but rather an upheaval. Before the Potsdam sandstone there is no evidence of high mountains. During upheaval, there is dislocation at the junction of the beds, forming a series of abrupt vertical cliffs, as seen in the succession of the strata of New York; in the case of denudation, the surface would be a series of general curves, which is not the case in New York. During upheaval the level of the sea may be actually less, from the contraction of the earth's crust while cooling; in consequence of this contraction the ocean would always remain at a certain depth, sufficient for these depositions of thousands of feet of strata during the upheaval of the land. The study of the fossils, also, is opposed to the theory of sudsidence and denudation, and we do not find those of the primary carried into the secondary beds.

IRON.

Manufacture of Iron by the Natives of Africa.—At one of the meetings of the Boston Society of Natural History, last March, Dr. Hayes submitted a letter from the interior of Liberia, Africa, in which the writer says that there is no occurrence there of native iron, as stated by him in Vols. V. p. 250, and VI. p. 279, of the Proceedings.

The piece there described was smelted by the tribe among whom the writer resided, who keep the art to themselves, as they find the manufacture of iron very profitable, the product of their furnaces being held in high esteem by the neighboring tribes, as a tougher and more flexible iron than they can obtain from foreign countries. The furnaces consists of stacks of about six by five feet, and about seven feet high, with a flue in the centre about two feet long by nine or ten inches wide; the flue, passing to the bottom of the stack, is filled with layers of coal and ore, upon which they force a strong current of air by rude contrivances ; nothing is allowed to escape but the dross, and a heavier brittle substance which they remelt in small furnaces ; the iron is left to cool in the furnace, which gives it the appearance of ore, with large particles of dross adhering to it, much blistered in places, with very rough protuberances over much of its surface. Many of these furnaces, with their banks of dross, may be seen in the interior of the country. The color of the ore, mostly of mountain character, is between cherry and brownish red, like red iron-stone. He had seen pieces of fifty or sixty pounds, the result of one blast. They cut the mass when heated with their rude axes as they do wood, showing the good quality of the article. The ore is plentiful in most parts of the country, and of varying quality. The masses of iron are in many places sold as they come from the furnace, but in the interior it is forged into pieces resembling a "pudding-stick," which are used as a medium of exchange in commercial transactions in the markets and in private barter. Africa has doubtless all the iron required for her extensive wants, and dense forests for the manufacture of the coal to work it. Dr. Hayes wished, therefore, to correct the error in the statement that native iron exists in Africa, to which he had been led by its texture and chemical composition, which were unlike those of manufactured iron in containing quartz crystals and magnetic oxide of iron, with no traces of carbon or its compounds.

The Manufacture of Semi-Steel at the Albany Iron Works—How to Treat it in the Arts.—Since the regular and guaranteed manufacture,

and the considerable and satisfactory use of steel, as a substitute for wrought iron, is now established in this country as well as abroad—since a metal a quarter stronger than wrought iron can be furnished at the price of wrought iron, the engineering and commercial world, in fact the whole public, can congratulate itself on a great stride in advance. Iron, the very type and substance of universal strength, is left behind by science, which now produces a stronger and more universally safe and useful product out of the same crude material. To the innumerable uses of cheap steel, and its chemical nature and general manufacture, we have already referred. A somewhat more detailed observation of the process of making a metal which is likely to come into wide-spread and most important use, will possibly be generally interesting.

The only establishment in the United States now making Semi-Steel—the metal referred to—is that of Messrs. CORNING, WINSLOW & Co., of Albany. The manufacture was commenced two years since, and was, in its earliest results, so successful as to warrant the erection of furnaces, steam hammers, rolls, &c., for its especial accommodation. The English house which has embarked in the new enterprise, attribute (often less complete) success to the fact that they have so long been engaged in cast-steel making as to possess that *indispensable* facility—skilled and experienced workmen. The Americans, however, less wedded to routine, and more self-reliant, if not more ingenious and observing, have not been obliged to take this view of the case. Some English workmen were at first employed, but did not materially advance matters. The native operatives, and the Canadian Frenchmen employed in the works, entered into the spirit of the improvement at once, and can now produce a uniform quality of steel.

The pig iron—Salisbury iron is preferred, it being naturally tough, and containing no appreciable phosphorus or sulphur, which respectively make the iron brittle when cold or hot—the pig iron, as it comes from the "blast" or smelting furnace, is broken up and placed in the refining or puddling furnace, and treated substantially, but not essentially, as if it were to be made into wrought iron, or fully decarbonized. It is, however, decarbonized, but not to so great an extent, for wrought iron contains but the fraction of a per centage of carbon, while semi-steel contains about one per cent. The original cast iron often contains five per cent. of carbon. The puddling process consists in placing the pig metal, broken into small pieces, on the trough-shaped fire-brick hearth of a furnace, removed from the solid fuel; the

flame passes over a bridge wall and is deflected upon the iron. For wrought iron, a quantity of cinder or iron scales, or both, are added to the cinder previously placed and melted on the hearth, the whole forming a bath in which the iron is heated under a constantly increasing temperature. In case of steel the cinder that runs from that kind of puddling furnace called a boiling furnace, where the iron is more intensely heated, in contact with an excess of cinder, is used in charging the steel furnace, instead of ordinary cinder. Other fixtures are used with the cinder, but their nature and proportions are not mentioned, as this part of the process is not made public, for obvious reasons. The heat applied is much more intense than that in case of iron-making. The cinder and fluxes "boil" from the escape of the gases caused by the oxydation of the carbon in the iron, and of the iron itself. The bath surrounding the iron being melted as thin as water, the decarbonization is more uniformly and rapidly effected. But the working of the iron in the furnace is a most important feature of the process. The operator stirs up the iron with a bar, breaking up the lumps as they become sufficiently heated, turning them over to expose all parts to the heat, and at last, when the mass becomes sufficiently soft and pasty, he rolls and works it into balls, in somewhat the same manner that snow balls would be rolled up and compressed. The balls are taken out of the furnace and placed under the steam-hammer. The continuance and intensity of the heat are regulated solely by the judgment of the operator. The appearance and softness of the metal, are the sole indications of its nature, and so readily does the experienced eye detect all these phenomena which, to the unpractised vision would be merely a white blur of flame, that the chemical quality of the products are never materially different. The process works out not only much of the carbon, but a large amount of other impurities. Such is the nature of the bath of cinder, &c., that a longer time is required to work the pig metal into steel than into iron. The same time is required to convert three hundred and thirty-six pounds of pig iron into steel as would be necessary to work four hundred and forty-eight pounds into wrought iron in a "boiling" furnace; and a higher heat is used, so that the expenses of manufacture are somewhat increased. The coal required for a ton of puddling iron is some sixteen hundred weight; for a ton of steel, a ton and a half of coal are used.

The puddle balls are hammered two together, into a slab, under a three-ton hammer. They are then heated and hammered twice at a welding heat. At the fourth heat they are rolled into boiler plates,

tire bars, or merchant bars. The slabs for tires weigh from six to twelve hundred weight each; four slabs making a locomotive tire. A little borax is placed between the slabs at the second heat, to facilitate their welding.

The manner of working semi-steel into the parts of machinery—all processes which require the treating and welding of the bars or plates as furnished from the forge, is a subject requiring early and especial attention, since a careless or thoughtless operator can ruin the metal entirely. Boiler plates, axles, and all sorts of merchant bar, have been sent back by consumers as worthless. This has occurred with the best English puddled and cast steels. The apparently worthless part has then been cut off by the makers, and the bar worked and welded with the greatest success. The secret lies simply in not *overheating*. Steel burns more readily than iron, but will, with proper care, weld as soundly and easily as iron. With the Albany steel, no borax is required, ordinarily, in welding, as proved by Government test. Should borax be needed for a high quality, that is, for a quality which contains nearly as much carbon as cast steel, it will leave the welded part harder than the rest. In this case it should be annealed by heating it to a low red heat, and cooling it in pine wood sawdust, which is better than ashes, the substance generally used for this purpose. Semi-steel is found, by blacksmiths and boiler-makers, who understand its nature—and this is most easily learned—to work, as they say, "like copper." Since, then, it is a quarter stronger, while its cost is not greater than that of iron, we believe it will rapidly come into general use in place of wrought iron.—*New York Times.*

COPPER.

Acton Copper Mine.—This interesting locality of copper, which was noticed in the January number of this Magazine, is now attracting great attention, and is yielding large quantities of ore. It is about two hours' ride from Montreal, by the Grand Trunk Railroad, and about half a mile from the Acton Station.

The ore occurs in a bed of limestone, and in strata of shale bordering it. These strata and the included ores trend nearly northeast and

southwest, and dip at an angle of forty-five degrees, to sixty degrees, to the northwest.

Attention was called to this locality about ten years ago, by Sir William Logan, the Provincial Geologist, but no explorations were made until last year, when the soil and drift were removed. The indications of copper were much greater than before, and an abundance of copper ore was found. An open cut was commenced, and up to this time about eighty thousand dollars worth of twenty per cent. ore has been taken out. Forty thousand dollars worth of this has been sold, and, according to the lessee, about the same quantity of ore remains on the surface, not yet dressed for market. At present the average shipments of ore are two hundred and fifty barrels of the twenty per cent., or about fifty tons, worth eighty-five dollars a ton.

The ore is chiefly the varigated copper pyrites, or purple copper, and occurs in seams or irregular patches ramifying through the limestone, or disseminated in fine grains or strings through the mass, or in a cherty rock which penetrates the limestone. At the main opening the ore is found distributed in this manner through the rock over a breadth of from fifty to a hundred feet, and it is also found in the shales on one or both sides, in the condition of the yellow sulphuret. The mine is worked under a lease, and looks like a great stone quarry. It can be worked in this way for a long time, but two or more shafts have been commenced, one in the shales and one in the limestone. Labor is abundant and cheap. Good miners can be had at forty dollars a month, and ordinary laborers for eighty cents a day. The ore is packed in flour barrels, and sent to Boston via the Grand Trunk Railroad, and Portland. No preparations have yet been made for dressing the poorer portions of the ore, of which a large amount is accumulating.

Copper in Arizona.—An interesting locality of copper ore, called the Maricopa Mine, has recently been brought to notice by Colonel A. B. Gray. It is near the left bank, or south side, of the Gila River, about forty miles above the Pimo and Maricopa villages. The ore is described as Tennantite and gray copper ore containing silver, by some, and as vitreous copper ore, by others.

Dendritic Copper, in Cubes.—Beautiful specimens of dendritic native copper occur in one of the veins at the McGruder Mine, Lincoln County, Georgia. It is found in flat sheets consisting of aggregations of cubical crystals with brilliant faces, sometimes beautifully tarnished.

The similar planes are parallel, so that light is reflected from a mirror-like surface when the specimen is turned back and forth. It is associated with pyromorphite, and a black ore of copper, like that at Ducktown, but it is not abundant.

SILVER.

The Stephenson Silver Mining Company.—We extract the following details respecting the mines of this Company in the Organ Mountains, New Mexico, from the Report of W. Herman Rittler.

The principal vein, or vein 1, is said to run due north and south, and to dip to the west, while the others bear twenty degrees east, and dip to the east. These veins are thus believed to intersect the north and south vein. The deepest workings on vein 1, are about fifty feet below the surface. The pillars which were left standing and the back and face of the vein show very rich and good ore. The average silver yield of the decomposed veinstone is found by assay to be about $70. These argentiferous veinstones may be used with profit for fluxing the principal or richer ore, but heretofore they have been thrown away as worthless. "The principal ore is an 'argentiferous and auriferous' galena," which occurs in large masses or bunches mixed with quartz, calc-spar, carbonate and sulphate of lead, and toward the north with green and violet colored fluor-spar, which is an excellent flux for the ore. Copper ore is associated with the galena, and where this is present the yield of silver is greater.

Mr. Rittler has made many assays of the ore from different parts of the mine and finds the yield to be from 20 and 60 to 500 dollars worth of silver to the ton. At one place, on vein No. 3, he obtained a small quantity of ore which yielded over 700 dollars to the ton, or 556·8 ounces.

Six different veins are described, all having ore rich in silver. They are said to show the action of the atmosphere to a considerable depth, the sulphurets being mostly changed to carbonates, sulphates and silicates. The change usually reaches a depth of one hundred feet, but at one point it is three hundred feet. Mr. Rittler closes his Report with the following observations upon the mining and smelting:

"While the former owner of the mine paid two dollars for three hundred pounds of clean ore, delivered down on the road at the foot of the hill, we will be able to reduce this price in a short time to one-half. We will save the expense of shaft-sinking; and driving the level always on the course of the vein, the ore from it and the ore from those places where it is justifiable to stope the vein, will not only pay expenses, but will leave an extra handsome profit.

"By an economical and careful management, we must and will have results satisfactory to all interested; and I hope soon to see our Hacienda enlarged, and a machine in operation to facilitate the smelting.

"The road from our mine to the Hacienda is excellent, descending gradually from the mine to the Rio Grande, therefore favorable for heavy loads, so that one ton of ore will not cost more than $2 in the beginning to transport; and estimating, for the commencement, the cost of mining at $10, (a very high estimate,) which will be $8 after a short time, we have the cost per ton of ore at the Hacienda, ready for smelting, at $12. Calculating the cost of smelting at $10 to $15 per ton at the commencement, (a very high estimate,) we have a total cost of $22 to $25 per ton of ore.

"Looking at the silver-yield of the different kinds of ore, according to assays, you may easily calculate the profit obtained. All these facts are based on experience; practice will prove its truth. Our veins are so favorably located, and the ore so well adapted for smelting, that our results will equal those of a mine richer in silver, but containing ores adapted only for amalgamation.

"The Hacienda, or smelting house is situated on the bank of the river, about twelve miles from the mine. It is built for this country, on an extensive and substantial scale, out of 'adobes.' The blast for smelting is furnished by a very ingeniously constructed mule-power machine. With the three new bellows we have to put up, and the horse power added, we shall be prepared not only to smelt the ores from our mines, but those of other mines in this neighborhood.

"The expenses of smelting are small; two good smelters, two good refiners, and two helpers are the only persons necessary—one party for the day-shift, the other for the night-shift; two mule drivers, and perhaps four mules, two per day and two per night, for moving the horse-power machine for bellows. This, I think, will at present be sufficient for the carrying on of our mining operations. The number of miners

will be also small, in order to correspond with our smelting operations; the fuel consisting of charcoal from mesquite roots and cottonwood.

"Our mines are inexhaustible, and, as my assays show, very rich in silver. The attention of the former owners of the mine was drawn entirely to the solid galena, which, in average, gave from $100 to $140 per ton; the richest ore was never noticed, and considered as valueless. I am not only acquainted now with the different silver-yield of the ore, but also with the appearance and nature of the richer ore, and will, therefore, show more attention to that than any other. We will have sufficient ore for keeping our furnace in constant operation; besides, we may buy up the richer ore delivered at the hacienda from different other mines which will soon commence operations. I therefore doubt that our present machinery will be sufficient for our operations.

"Water-power can be had by constructing a canal, which, however, will be very expensive to build, and expensive keeping it in repair, or by building new smelting works on the canal (ascequia) at Las Cruces, four miles up the river. As my time has been so much occupied, I could not inform myself much on this subject; my opinion, however, is, water power will not be sufficient, and entirely too expensive."

Heintzelman Silver Mine.—Mr. Henry Howe has recently issued a statement to the stockholders of the Sonora Exploring and Mining Company, by which it appears that the total yield of silver from the mine is not less than $100,000 up to January 1st, 1860. The Secretary, in his last Annual Report, gives the total yield as $24,000. This, Mr. Howe says, is the yield from the amalgamation works for a period of ten months only, from March, 1859, and this with the defective machinery. At last accounts the new engines and machinery had arrived at the mine, and were soon to be set up. Col. Talcott, formerly of the army, has been appointed Superintendent of the Company's mines and smelting works.

Stephanite—Brittle Silver ore—from Washoe.—In commercial samples of the silver ores from the Washoe mines sent to New York, I have found fine specimens of *Brittle Silver ore*, or *Stephanite* in imperfect crystals, weighing from one to three ounces. Before the blowpipe it gives a large globule of silver and decided reactions for antimony, arsenic and copper. This mineral contains about sixty-eight per cent. of silver, and is probably the principal form in which the silver occurs with the other minerals of the vein. In most of the massive specimens of the ore where galena is the principal mineral visible, small filaments

of virgin silver may be seen in the cavities or ramifying through the mass. This silver probably proceeds, in part at least, from a change in the Stephanite.

This species is found with other ores of silver in the principal silver mines of Europe, at Zacatecas in Mexico, and in Peru. This is the first time it has been observed within the limits of the United States.—*W. P. Blake.*

Silver Glance from North Carolina.—Sulphuret of silver occurs sparingly in crystals of considerable size in the ore of the Silver Hill mine—formerly known as the Washington or Davidson County mine. It is probably *Silver Glance,* but contains a notable per centage of copper and lead.—*W. P. B.*

Ophir Mining Company—Washoe.—The first legal organization of a Company to work a Silver mine in the Washoe region has been finally completed by the election of the following officers of the "Ophir Mining Company," viz:

President—William Blanding.

Trustees—Theodore Winters, S. P. Dewey, Benjamin Holladay, William M. Lent, Charles F. Lot, Joseph Woodworth.

Secretary—James W. White.

Treasurer—W. C. Ralston, (of Fretz & Ralston.)

General Superintendent—Capt. W. L. Dall.

GOLD.

The Fields Gold Vein.—The remarkable vein of gold discovered in the bed of the Chestatee River, Dahlonega, Geo., a year or two since, has as yet bêen little worked, owing to the financial embarrassments of the former proprietor and the difficulty of keeping out the water of the stream during freshets. A temporary dam was built around the opening after the spring floods, and the pit cleared. The vein in the bottom was without the large masses of gold which had characterized it above, but afforded ore that paid handsomely to crush in hand mortars with pestles attached to spring poles. At last accounts, however,

heavy gold had again made its appearance in the vein, and preparations for active work were to be made. The pit is not over fifteen feet deep, but has yielded about 10,000 dollars worth of gold in beautiful specimens, associated with telluret of bismuth and other minerals.

COAL.

Origin of the Albert Coal of New Brunswick.—At one of the recent meetings of the Academy of Natural Sciences of Phiadelphia, Prof. W. B. Rogers communicated the result of observations which he had made within the last year on the structural and geological relations of the Albertite or so-called Albert Coal of New Brunswick.

An examination of the mine afforded, as he thought, convincing proof that this remarkable accumulation of asphaltic material could not have formed a part of the regular carbonaceous deposits of the region, —that it is not and never has been a true bed or stratum, but that it should rather be regarded as a mass collected within an irregular fissure of subsequent formation, by the distillation or infiltration of asphaltic matter from the surrounding bituminous shales.

The princpal feature of the deposit pointing to such an origin are— the very limited extent of the mass longitudinally traced,—its sudden and great irregularities of thickness and trend, and the yet more striking fact of its transverse direction in many parts of its course, as compared with the bedding of the adjacent rocks. In the lower level at a depth of about four hundred and sixty feet where the combustible material has been removed almost entirely from end to end, the slaty rocks are seen in many places abutting against the sides of the mine at a steep angle, presenting frequently a jagged surface, such as would result from a transverse fracture and a gaping of the strata. The Albertite was seen adhering to these irregular surfaces, as well in the cavities as on the projections, affording, even in hand specimens, excellent examples of the discordance of the mass as to position with the stratification of the contiguous rocks.

It is worthy of note that the material thus adhering to the walls of the mine has none of that intermixture with earthy sediment which so often marks the contact of regular coal seams with the enclosing strata, but maintains the same remarkable purity as in the midst of the mass.

It is, moreover, quite free from the carbonaceous and rocky debris, and other marks of machanical violence which it must have presented had it originated in the dislocation and displacement of a coal seam originally conformable with the stratification of the neighborhood.

These evidences of the nature and origin of the deposit are confirmed by the statement that in the progress of the mining several large fragments of the vertical wall-rock have been found detached and imbedded in the midst of the Albertite, and on one occasion a mass of unusually great dimensions could be traced by correspondence of form to a cavity in the wall at some distance above, from which it would seem to have fallen, while the contents of the fissure were still but imperfectly solidified.

The conclusions of Prof. Rogers, as to the origin and nature of this remarkable deposit are thus completely in harmony with those which Prof. Leidy has maintained on the ground of a microscopic examination of the material.

Petroleum Wells, or Oil Springs of Western Pennsylvania.—According to letters received by Prof. R. E. Rogers—*Proc. Acad. Nat. Sci. May*, 1860—it appears that some of the Petroleum wells of Western Pa. had already begun to show a diminished yield of oil. This fact is in confirmation of an apprehension which he had expressed at a former meeting of the Academy that when Artesian borings became more numerous in the favorite localities there was a probability of such a result. Prof. Rogers regards the circumstance of even a small reduction in the supply of the oil from any of the wells at this early stage of the enterprise in that region, as very significant, and suggestive of the fear that, remunerative as these wells may at present prove to be, it may not be prudent to base permanent calculations upon them.

MISCELLANEOUS.

Cast Platinum.—At the last sitting of the Academy of Sciences, MM. Deville and Debray exhibited two ingots of platinum weighing together a little over 55lbs. av., which had been melted in the same

furnace and run into an ingot mould of forged iron. The furnace used was that described in the *Chemical News*, vol I, p. 6. The authors announce that platinum may be melted in any quantity, and once melted, it behaves precisely like gold or silver, requiring exactly the same precautions as in casting the precious metals. They also exhibited a platinum cog-wheel, cast in an ordinary sand mould in the same way as other metals, thus giving a new proof of the possibility of giving plantinum all the forms that may be desired by their process.—*Chem. News*, June, 1860.

Origin of Phosphate of Lime and Phosphates.—St. Clair Deville, in an article upon artificial species of metallic phosphates,* remarks upon the formation of apatite—Phosphate of Lime—as follows:

"The occurrence of apatite in veins has led M. Daubrée to think that this substance may have been conveyed into its position in the form of volatile products, and in particular by the action of chloride of phosphorus on lime—a reaction which in fact produces apatite, for it brings together chloride of calcium and phosphate of lime. The presence of fluorine would be more difficult to explain on this supposition; but an observation we have made renders the hypotheses of M. Daubree admissible under much simpler conditions. In fact, apatites and wagnerites become volatile at a slightly elevated temperature in the vapor of metallic chlorides, in the midst of which they are formed. We have thus been able to distill, at a red heat, wagnerite in the vapor of chloride of magneisum; and the volatilized crystals which were analyzed had the constitution of the primitive substance. Apatite, also, volatilizes in the vapor of chloride of calcium; and by using carbon vessels we have obtained beautiful crystals of sublimed apatite. This singular phenomenon may be classed with certain well known facts, such as the volatilization of boracic acid in aqueous vapor, of sulphide of boron in sulphuretted hydrogen, &c. It appears evident that these phenomena are not purely mechanical; and when they have been studied, they may contribute to explain various facts of nature."

Diamond Deposits of India.—In a notice of a recently issued volume of the "Memoirs of the Geological Survey of India," the London

---

* *Compte Rendus*, Dec. 20, 1858. See also *Lon. Dub. and Edin. Phil. Mag.*, Vol. xvii, No. 112.

Athenæum gives the following abstract of descriptions of the mode of occurrence of diamonds.

The great majority of the diamond diggings are diluvial. Against the sides of the outlaying ledges there are deep deposits of "kunkurry" and chloritic clay, in which great pits are dug in order to get at the layer of coarse subangular cherty gravel, in which diamonds are to be found. The most interesting of the diluvial mines are those of Udesma and Sakeriya. The former are in active work, but water often finds its way into the pits. Here, the best material is a stiff unctuous clay with quartz gravel dispersed through it. There are other diamond workings in the gorge of the Boghin, which must be alluvial, as the entire excavation is to be attributed to the action of a river. The natives remove some twelve feet of dark brown clayey sand to get at the boulder bed, in the base of which diamonds are found; but both here and below the narrow gorge the gravel at the surface of the river bed is much worked. Hereabouts, some twenty years ago, an European made an attempt at mining on a large scale, but with what success is yet to be discovered, although the remains of his wash-pits and picking-floors still testify to his enterprise. The author says little to encourage future undertakings of this kind, and, in fact, it is difficult to say how far the sagacity of the natives may have rightly determined the precise limits of the diamond rock. Within certain areas the ground is almost exhausted, and the natives never attempt rock diggings beyond these areas, probably for sufficient reasons. Yet it seems warrantable to infer that not a few gems "of purest ray serene" are distributed over this pebbly conglomerate and mingled with the diluvium and alluvium of the neighborhood. The limits of the rock-deposit should be traced, as in this part of India the rock diggings for diamonds are the most valued.

Cause of the rapid Decay of Timbers of Ships.—In the first number of the Chemical News we find a translation from the *Comptes Rendus* of an important communication by F. Kuhlmann, upon the oxyds of iron, considered as a means of conveying the oxygen of the air to combustible matters. He gives, in conclusion, the following general statements:

"The results of my experiments, and all these facts of daily observation, appear to be conclusive in making chemists to admit that sesquioxide of iron may serve to convey the oxygen of the air to organic matters, and thus hasten their destruction. The oxyd acts, to a

certain extent, as a reservoir of oxygen, filling itself at the expense of the air in proportion as it empties itself for the profit of the combustion of combustible bodies."

From this it will be seen that in all constructions of wood and iron combined, where the latter becomes oxydized or rusted, the wood will rapidly decay. Mr. Kuhlmann, in passing through the dock yards at Dunkirk, observed that the fragments of a ship then being broken up were most decayed where the iron bolts or fastenings had penetrated, and he is satisfied that the rapid decay of ship timber is due, in great part, to the iron nails and bolts. He suggests that the evil may be avoided by coating the iron with tin, or zinc, or by replacing it with copper.

BOOKS AND MINING REPORTS RECEIVED.

The Ventilation of Mines. By Ralph Moore, Mining Engineer, Glasgow. 8vo. pp. 69. Glasgow. 1859. Imported by Bailliere Brothers, 440 Broadway, N. Y.

This treatise is designed to be a useful work of reference for the underground managers and overmen employed in the Scottish Mines, or mines which do not require more than ten thousand cubic feet of air per minute. The principles, as far as enunciated, are applicable to ventilation generally, while the details of fittings, furnaces, and the like, refer especially to mines as above stated.

The book is copiously illustrated by drawings upon wood.

Prospectus of the Southern Zinc Company. With a Report upon the Company's Mines, Union County, Tennessee. With a Map. 8vo. pp. 19. 1860.

Report [and Statement] *upon the Property of the Valley River Gold Company,* Cherokee County, North Carolina. With a Map. 8vo. pp. 16. Boston, June, 1860.

Report upon the Property of the Cherokee Gold Company. 8vo. 1860.

The Silver Hill Mining Company, Silver Hill, North Carolina. With the Report of Thomas Petherick, Esq., Mining Engineer. New York. May, 1860.

Second Annual Report of the Santa Rita Silver Mining Company. Made to the Stockholders, March 19, 1860. 8vo. pp. 20. Cincinnati. 1860.